ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. [illegible] No. 7. 220 Broadway, New York, February 13, 1908.

TABLE OF CONTENTS.

LEADING ARTICLES:	Page.
The Construction of the Portland & Seattle Ry. (illustrated); W. P. Hardesty.	161
Design and Construction of Automatic Car Systems (illustrated); C. J. Steffens, M. Am. Inst. M. E.	165
A Pile-Girder Bridge Replacing a Bowstring Truss in Washington, D. C. (illustrated); W. J. Douglas, M. Am. Soc. C. E.	167
Swamp and Overflowed Land Drainage in the Mississippi Basin; F. W. Hanna.	168
The Reclamation of Minnesota's Wet Lands; G. A. Ralph.	170
A New Trench Excavating Machine (illustrated).	170
The Panama Canal—A Brief Statement of Work, Equipment and Finances.	171
The Transportation Problem in the Portland Cement Plant; C. J. Tomlinson.	171
A Pleasing Concrete Block Residence (illustrated).	178
Report of the New York State Water Supply Commission.	178
Othniel F. Nichols (with portrait).	179

	Page.
EDITORIAL	173
Concrete and the Labor Unions—The Dangers of Broken Rails—A Notable Railway Through the Columbia Gorge (illustrated).	
The Future of the Chicago Drainage Canal (illustrated).	173
LETTERS TO THE EDITOR	175
The Comparative Costs of Operating Private and Municipal Pumping Plants; I. H. Reynolds—Advertising Defacements in the New Washington St. Rapid Transit Subway, Boston, Mass.; W. T. Howe—The Waterproofing of Concrete; M. H. Lewis—The Function of the Consulting Bridge Engineer; J. A. L. Waddell—Waddell's Tests of Carbon-Steel and Nickel-Steel Columns; C. P. Buchanan—Notes and Queries.	
ENGINEERING NEWS OF THE WEEK	179
PERSONALS	180
ENGINEERING SOCIETIES	180

THE CONSTRUCTION OF THE PORTLAND & SEATTLE RAILWAY.

By W. P. HARDESTY,* C. E.

The Pacific Northwest has had its full share of the great activity in railway building of the past two or three years. In the early spring of 1907 the Pacific Coast group of states had a larger mileage under way than any other group. In this group the State of Washington far outstripped any of the others in its mileage under construction.

The new Portland & Seattle R. R. is to run from Portland, Ore., to Kennewick, Wash., where it connects with the Northern Pacific Ry. In effect it serves as a short line for the Northern Pacific to Portland from the East. The latter now reaches Portland from Puget Sound, which involves the long detour from Kennewick northwesterly to Tacoma and thence south to Portland, including the climb over the Cascade Range of mountains. It also gives the Great Northern Ry. a direct line to Portland from the East, by connection at Spokane.

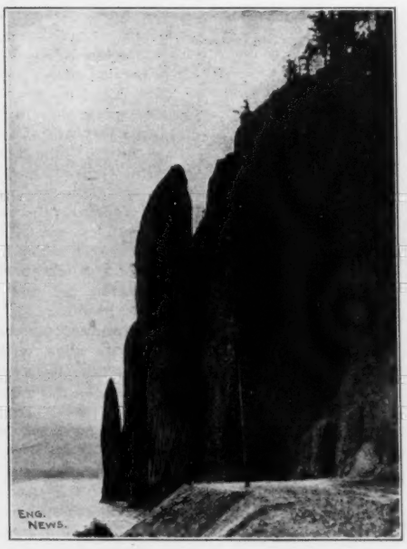
The new line follows the north bank of the Columbia River practically all of the way, and thus secures a very low grade. The Columbia River is the only stream that breaks through the Cascades from the East at any point on this high mountain range in Washington and Oregon. It is, in fact, the only stream in the United States that cuts through such a high range as the Cascades, and the stream itself is but very little above sea level. The river valley is therefore the natural route for any through railway line bound for the north Pacific Coast or for Portland.

The Portland & Seattle R. R. runs from Portland down the westerly or left-hand bank of the Willamette River for about five miles, when it crosses to the right bank and cuts through the "Peninsula" between the Willamette and Columbia rivers and thence crosses the latter to Vancouver, Wash., a distance of ten miles. It then follows up the right or northerly bank of the Columbia all the way to Kennewick, a further distance of 220 miles. The total rise in the railway grade from Portland is only 324 ft.

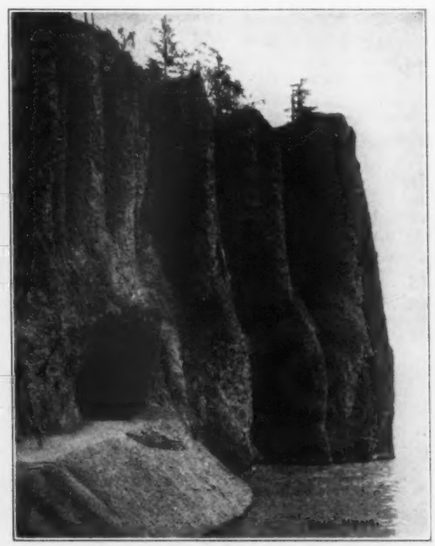
PHYSICAL CHARACTERISTICS OF THE COUNTRY TRAVERSED.—Along the Columbia for the entire distance, and for a number of miles each side, the geological formation is of volcanic origin, and lava is the only rock found—usually a basalt.

The Columbia is confined between hills or plateaus nearly all the distance followed by the railway, so that the latter nowhere lies more than about one mile away, being usually along or near the bank. For a distance of about 65 miles, extending from The Dalles, Ore., to a point about 20 miles easterly from Vancouver, Wash., the Columbia runs through the "Gorge," the latter being the opening through the Cascade Range before noted. This portion contains the heaviest rock and tunnel work on the line.

At The Dalles, the canon of the Columbia opens out into the arid plateaus of eastern Oregon and Washington, distinct in climate and topography from the western portions.



View of East Portal.



View of West Portal.

TUNNEL THROUGH "CAPE HORN," PORTLAND & SEATTLE RY., COLUMBIA RIVER GORGE, WASHINGTON.

STANDARDS OF CONSTRUCTION. — The same standards are used for the entire line, and are as follows: Maximum grades, eastbound, two-tenths of one per cent. (0.2%), no adverse grades for westbound traffic (except in Oregon); maximum curves 3°, all curves of 1° 30′ and over being spiraled. On curves the 0.2% grade is compensated at rate of 0.04% per degree, so that on a 3° curve it reduces to 0.08%. The roadbed for single track is 18 ft. for fills and 24 ft. for cuts, and for double track it is 32 ft. and 38 ft. respectively. The track is elevated for a speed of 60 miles per hour on curves up to 2°, but for only 45 miles on 3° curves.

Passing sidings were made 4,500 ft. long, but where in cuts the latter were taken out for a full mile in length. The side slopes given rock cuts varied from ¼ to 1 to 1 to 1, depending on firmness of formation. Loose rock slopes are 1 to 1 to 1½ to 1, hardpan and firm earth 1 to 1, while light earth and sand cuts are 1½ to 1. In rock cuts the roadbed width is only 18 ft., as side ditches are not ordinarily needed. Earth fills have 1¾ to 1 slopes and rock fills 1½ to 1.

To ensure being entirely above any floods of the Columbia, the grade is nowhere less than 7 ft. above the greatest recorded high-water, that of June, 1894, when the river reached, on an average, about 10 ft. greater height than has been known before or since.

The aim is to make the roadbed of the most permanent character. Although trestling has been used in several places, where material could not be secured to make the embankments, the intention is to fill this in by construction train after the road is put into operation. All permanent openings are spanned by either steel or concrete structures, the latter being used for spans of 6 ft to 16 ft.

GENERAL DESCRIPTION.

At the Portland end of the line the road is double tracked for a distance of 33 miles. For 20 miles at the Kennewick end the line is also double tracked. This provision will prevent obstruction to the denser traffic near the terminals. The general contractors for the entire line were Siems & Shields, of St. Paul, Minn.

For construction the line was divided into eleven divisions, each in charge of a division engineer. Each division was subdivided into two or three residencies, averaging 8 to 10 miles in length. The divisions were numbered in order, beginning at the Kennewick end. The writer visited divisions Nos. 6, 7, 8, 9, 10 and 11, which take in very much the greater part of the heaviest work.

Beginning at the Kennewick end, the first ten miles runs through an open plains country, with but little heavy construction needed to secure very direct alinement. There is one tangent over eight miles long coming out of Kennewick. There are only three of the 3° curves in a distance of 60 to 75 miles out of Kennewick. Long light curves are used where possible, even for the large angles, and in one place is a 0° 34′ curve about two miles long. The more simple methods of excavation could be used to advantage on this part of the road, and but very little team and scraper work was done west of a point

*401 Seventh St., Portland, Oregon.

shortly below Celilo Falls—about one-half way. In some places the line runs some distance back from the river. Opposite Irrigon (on the Oregon side) the line was located about one mile back, in order to get back of a series of sand dunes and hills next to the river, the drifting of which would be objectionable. It may be here remarked that on the Oregon Railroad & Navigation Company's line, which runs along the other side of the river, the drifting of the sands is a decided obstacle and expense in operation. The sand banks and dunes are mostly composed of sand that blows off bars in the river when exposed during low water. Fences are used to stop the sand, the same as snow fences in other parts of the country, and they greatly reduce the amount of sand to be shoveled from the track.

Just above Umatilla, where the O. R. & N. main line from the East first strikes the Columbia, the river runs in a canon, and there is about 25 miles of heavy work along here for the Portland & Seattle road. Opposite Umatilla there is a 650-ft. tunnel through a rocky point. Just above Celilo Falls there is another tunnel 374 ft. long. For about two miles each side of Columbus there is also heavy work.

DIVISION NO. 6.—This division reaches from Celilo Falls to Lyle, a distance of 20 miles. Twohy Bros. were the subcontractors for the lower 15 miles. Parsons, Winter & Boomer had the upper five miles, and also a lot of work adjoining on Division No. 5. Mr. T. C. Hanford was the division engineer.

On this division the greatest fills have a center height of about 80 ft., the lower slope taking 100 to 110 ft. The maximum cuts are about 75 ft. on the center line and 80 ft. on the upper side. The largest single fill contains 125,000 cu. yds., and the largest cut about 63,000 cu. yds. About 2½ miles above Grand Dalles a large depression enters the river, forming what is called Big Bay. A fill is used here, 600 ft. long over all and 65 ft. maximum height, and, as it was made with dump cars, the contractor's trestle had to be built the full height. The fill contains 88,000 cu. yds. At another place a bay in the river is filled across, the depth of water being 40 ft. at low stage. At another place the contractor used a suspension bridge, made of two wire cables stretched across the ravine to be filled, held to gage by the ties laid on them. The dump cars were pushed on to this by the dinky engine, which remained on land. This was a rock fill.

The total amount of material moved was about 2,000,000 cu. yds. Approximately 50% of this was solid rock, and very little of it was earth. The classification of material used on this road was as follows: Earth, shell rock (small broken rock), hardpan, loose rock (½ cu. yd. and under) and solid rock.

In excavating along the cliffs and the talus below them as for two or three miles near Grand Dalles, the following method was used: Small tunnels, about 2½ × 3 ft., called "coyote holes," were run into the hillside at intervals of about 50 ft., each to a depth of 20 to 40 ft. From the end of which a "T" or cross-cut was run, and they were then filled with black powder and a string of them blasted at once. There is trouble in springing drilled holes preparatory to use of black powder, as the lava rock is so brittle that it cracks far out, and the black powder is then partly lost in the fissures, and it is hard to fill in tight and confine.

On this division has to be overcome the drop in the river at Celilo Falls and some long rapids below there, there being about 80 ft. fall in ten miles distance during low water. During the extreme high water the surface slope of the river becomes fairly uniform over this stretch, and the grade is then approximately parallel to this slope.

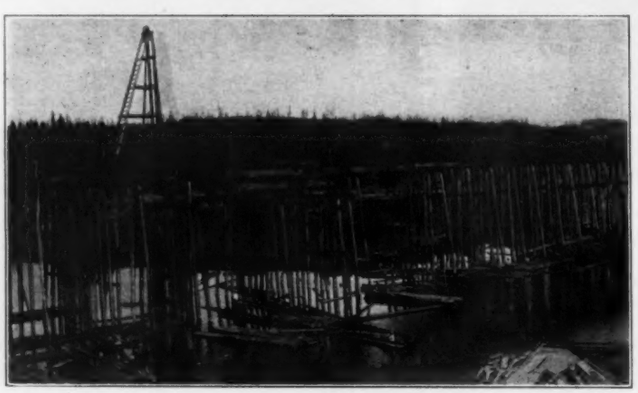
DIVISION NO. 7.—The country covered by this division, 19 miles in length, is typical of the Columbia Gorge. The mountain slopes bordering the river are steep and rocky. Along much

Excavating 100,000-Yd. Cut About Four Miles Above Cape Horn Tunnel, Portland & Seattle Ry.

(Working tunnel driven through hill first and timbered. Holes made in roof at about 25-ft. intervals as toe of slope recedes to it, and material poured through into tram-cars.)

of it there are terraced cliffs of different heights, usually far enough above the river to afford space for a railway built along the talus below. For much of the distance there is a narrow strip of bottom land (subject to overflow) or of tapering slope from the main hillside. As this loose material contains boulders and smaller rocks, there usually is much classified material. At many projecting points the cliffs come directly down into the water, presenting an almost vertical face, so that a tunnel is unavoidable.

The subcontractors on this division were: Caughren & Woldson on upper 10 miles; Jones & Onserud for next 4 miles; and Grant, Smith & Co. for the remainder. The latter company also had the contract for all of the concrete work on the line from Lyle to Vancouver. The division engineer was Mr. G. D. Ball.



BUILDING DOUBLE-TRACK PILE TRESTLE ACROSS WASHOUGAL RIVER BOTTOM.

There is a greater number and length of tunnels on this division than on all the rest of the road. At the upper end are four tunnels, ranging from 480 to 1,170 ft. in length, all within one mile. Below White Salmon River are five more, ranging from 122 to 635 ft. in length. The total length of the nine tunnels is 4,720 ft. The eastmost tunnel is all on a 2° 30' curve, a part of another one is on a spiral. On this division all drilling, both in tunnels and outside, was by hand.

There are three different sections of tunnels used. No. 1 is for solid rock where no timbering is required, and it is excavated 16 × 22 ft., the subgrade being 2 ft. below top of rail. No. 2 requires timbering, but the timbers can be pulled before lining. Section No. 3 is used where the timbers cannot be removed, as the concrete lining is put in. In No. 2 a 2-ft. thickness of lining is put in, extending back to the excavated surface. In No. 3 the lining extends back to face of the timbers, the space between the timbers being ordinarily filled with muck. The thickness inside of the timbers is 2 ft.

All timbers are 12 × 12 ins., including wall-plates and sills, and the lagging is 4 ins. A 5-segment arch is used. The normal spacing of timbers is 4 ft., but it varies from 2 ft. to 8 ft. The concrete lining was made of 1:3:5 mixture, usually with broken stone.

About two miles from Mosier (on the Oregon side) was a place where the nearly vertical basaltic cliffs came down to the water, leaving no room for a roadway. Here a huge blast was made as follows: A small tunnel was run on the level of the railway grade for 50 ft. into the cliffs, from which two branches, or drifts, were run at right angles, one for 75 ft. and the other for 45 ft. In these three openings black powder to the amount of 1,400 kegs (25 lbs. each) was placed, with small rock tamped behind. The blast resulted in the cliff for a height of 180 ft., front of 200 ft. and 50 ft. back, being thrown down into the river and broken into fragments, mostly no larger than a man's head. About 40,000 cu. yds. were moved, and most of it fell into the place needed for the grade.

The total amount of material moved on the division was about 2,000,000 cu. yds., of which about two-thirds was solid rock and only about 10% earth.

This division has a much greater amount of trestle work than any other. There are seven pile-trestles, with an aggregate length of nearly three miles. Just west of the Klickitat River, running across "Mosquito Flat," is a trestle 5,376 ft. long. This has an average height of about 35 ft., and the piles were driven 20 to 25 ft. into the ground. One of the trestles is an approach to the bridge across the White Salmon River, reaching a height of 50 ft. The piles are all of Washington fir, and they were driven with a 3,600-lb. hammer.

The standard pile bent used on this road consists of six piles, with 10 ins. as minimum size of small end. It is braced with 3 × 10-in. pieces and has a 12 × 14-in. cap. There are six main and two jack stringers, each 8 × 16 and 28 ft. long, so as to cover two spans. All timber trestles are but temporary.

Just below Lyle the Klickitat River is crossed with a 160-ft. span reinforced concrete arch bridge. The abutments are founded in excavations in the solid rock formation composing the high banks of the river. The span is 160 ft., rise at center, 36 ft.; depth of arch at crown, 4 ft., at ends, 7 ft.; distance between centers of arch ribs, 10½ ft. The track rests on a reinforced concrete slab supported by reinforced concrete pillars footing on the arch. The contractor is the Contracting & Engineering Co., of Tacoma, Wash., which has also erected the reinforced concrete portions of the viaduct in Vancouver.

For cast-iron pipe culverts, here and elsewhere on the line, the standard sizes are 24, 36 and 42 ins., in lengths of 6 ft. In earth fills, dry walls are used for bulkheads, and nothing at all in rock fills. This division belongs to the portion of the country traversed that has a plenteous rainfall. The slopes above the line are usually steep and the material is such that it will not hold water, so that for the most part it is entirely impracticable to use surface drain ditches.

DIVISION NO. 8.—This division of 18 miles comprises the section opposite the Cascade Rapids. Mr. Fremont Crane was division engineer. Porter Bros. & Welch were contractors for

the line from the upper end of this division to Vancouver, a distance of 65 miles.

This division contains about the heaviest grading on any on the line. Opposite the Cascade Locks are two cuts, each containing over 300,000 cu. yds. One is 2,600 ft. long, has a maximum center depth of 66 ft. and an average of about 50 ft., being partly sidehill and partly thorough cut. The other one is 2,100 ft. long and has a maximum center depth of 97 ft. It was staked out at 1 to 1, which gave a maximum of 120 ft. on upper side, but on account of sliding in back of this the actual cut was about 200 ft. Just above these two cuts is a 420,000-yd. fill, made from them.

Just below Stevenson is a 340,000-yd. fill, mostly borrow, which is 2,800 ft. long and has a maximum center height of about 50 ft. About two miles above Stevenson is a short cut with 76 ft. maximum center depth that was practically all solid rock.

A wholesale application of the burrowing or undermining system in making blasts, which was found to be so well adapted to the work needed here, was made in cutting through a ridge of loose rock and solid rock at Cook's Landing. The maximum center cut here is 90 ft. Four or five "coyote holes" or small tunnels were run into the hillside for about 80 ft., and at the face of each a "T" or cross-cut was run for 20 or 30 ft. each way. In the T's and the main holes were placed sacks containing 2,385 kegs (25 lbs. each) of black powder. All of this was for one blast, but about 500 kegs failed to go off at that time. Of the 90,000 cu. yds. in the cut, nearly all was loosened up so that it could be removed with steam shovel, only a few small shots being needed during the shovel work.

The total amount of material moved on the division was about 2,700,000 cu. yds., an average of 150,000 cu. yds. per mile. Of this, about 25% was solid rock, 25% loose rock, not over 10% earth, and the balance shell rock and hardpan.

Opposite the Cascade Rapids is a prominent broad ridge or plateau called Sheridan's Point, which requires a considerable detour to the south to round it. An alternate location was made calling for a tunnel under this ridge. The average elevation of the surface on the tunnel line is about 170 ft. above grade. The tunnel would be 7,000 ft. in net length, and it would save just one mile in distance and 288° in curvature over a surface line. On the plateau above is a large lake, directly over the line and about 100 ft. deep in places. The ground adjacent is of boulders and other drift interspersed with quicksand veins. As it was manifest that a tunnel would be very difficult to build and maintain, the surface line next to the river was chosen.

DIVISION NO. 9.—The most interesting construction on this division was the Cape Horn tunnel. Cape Horn is a noted landmark 25 miles above Vancouver and a few miles within the mouth of the Columbia Gorge. It consists of nearly vertical cliffs, which come directly down into the river. Along this stretch of nearly a half mile there is no supporting ground on which a railway grade can be built, so that it is necessary to tunnel through the cliffs.

The tunnel is 2,350 ft. long, and its greatest distance back from the face of the cliff is 100 ft., varying from this to 30 ft.—at a point about one-third the distance from lower end. The basaltic cliff has a columnar structure, the columns being hexagonal in plan and varying from about 1 ft. to 1½ ft. diameter at the tunnel level, and 2 to 3 ft. nearer the river level.

A mistake was, quite naturally, made in the method of work first adopted for the tunnel by assuming that it would be ordinary solid rock. In blasting the rock broke into fragments varying from concrete-size up to 3 or 4 ins. through. No. 1 Hercules powder was first used, but this was changed for No. 2, and it was finally found that ordinary stumpage powder (No. 3) was best adapted to the work. The latter answers in this kind of rock just as well as the stronger powder, and it has the great advantage that its fumes after blasting are much milder—so mild that the workmen do not usually go out of the tunnel during blasting. The rock is hard to drill, but it is so brittle that it breaks up very easily, and it is reduced to a size for shoveling without further work. It breaks off so "short" in blasting that it can be worked very close to line, so that after trimming, the sides and roof present a remarkably clean and uniform surface.

Drilling was done with air drills, supplied from a compressor plant located at Cape Horn station, about a fourth of a mile above the upper end of the tunnel. This plant also supplied electric current for lighting. In driving the heading there were used, part of the time, four drills at the breast, two on a column, but after a round of holes two were taken back and mounted on tripods and started to work on the upper bench. On the next lower or main bench, back of the last, two drills on tripods were used. All holes were usually put in about 10 ft. and blasting was ordinarily done only once each 24 hours.

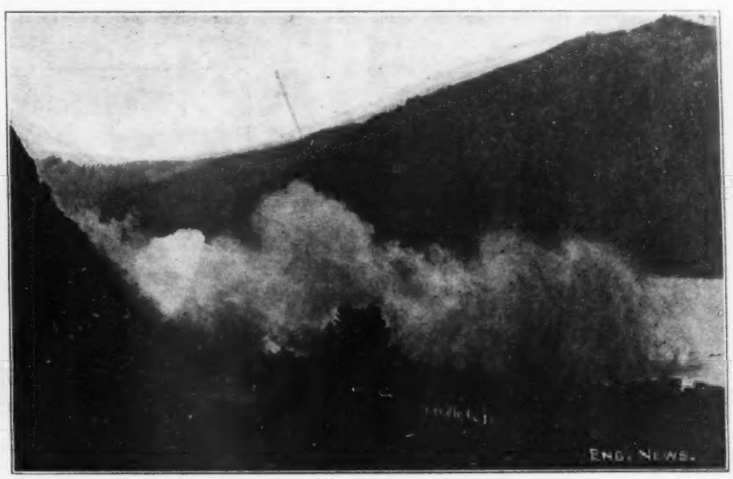
Mucking was first done by hand, and everything had to be shoveled. The method finally adopted was as follows: A frame called a "Jumbo" was made, mounted on wheels running on rails near the sides of the tunnel. About 8 or 10 ft. above the tunnel floor was a platform, on which was mounted a small steam hoist which used compressed air in place of steam in its cylinders. From its hoisting drums two ⅝-in. cables led towards the heading, and were attached to a scraper, which was a home-made tool holding about 1 cu. yd. One cable was used in pulling forward the load and the other served as a back-line. To scoop up and fill, about three men handled and held down the scraper. It took muck from the heading and from the first level below it. It was pulled an average distance of 75 ft. to 100 ft. to the trap on the platform, for dumping into the cars. The scraper generally ran in a scooped-out place in the material itself, the muck being worked down from the sides and from the back-end by shovelers. An open wooden chute led on to the platform from the muck-pile, to complete the runway. At the platform trap an attendant detached the cable from the scraper bail and connected it to a hook at the top of the bucket, by which the pull of the cable dumped the scraper. The muck below about the level of the platform had to be shoveled into the cars.

For hauling out the muck there was used a light electric railway, 2-ft. gage, with home-made locomotives of 8 or 9 tons weight equipped with 50-HP. motor. The dump-cars, each of about 2 cu. yds. capacity, were made up into trains of 5 to 8.

From the power-house a 4-in. pipe conveyed the compressed air to the tunnel. Just outside of the portal was placed a fan, which was run for an hour or two after blasting, to draw out the foul air through a 20-in. suction pipe.

The tunnel took about one year to drive, the contractor being ordinarily short of help. Two shifts of 10 hours each made on an average about 8 ft. per day.

View at Instant of Firing.
(Photograph taken at a point 1,300 ft. away.)



View 10 Seconds After Firing.

FIRING A 30-TON BLAST NEAR COOK'S LANDING, WASHINGTON. PORTLAND & SEATTLE RY.

The division engineer for this division was Mr. James Coyle. The resident engineer in immediate charge of the Cape Horn tunnel was Mr. E. Friday, and Boyington & Stevens were subcontractors for the same.

DIVISION NO. 10.

This division first included all the remainder of the line to Portland except the Columbia and Willamette bridges, the construction of which was segregated from that of the rest of the railway. Included in it are the extensive yards at Vancouver and the large freight houses at Portland. Mr. W. A. Grondahl was division engineer for a portion of the time during construction, after which the division was divided in two at Vancouver.

The U. S. Government made a requirement of 6 ft. clearance above the 1894 high-water mark for the lowest bridge members of the Columbia River bridge. As it was figured that 6 ft. more would be required by these members and the track system, the railway grade here was made 12 ft. above the high-water mark, and it was made level for many miles above here. On account of this great height, which is about 45 ft. above extreme low water, the line keeps well back from the river shore through Vancouver, and it is elevated above the ground by a viaduct nearly all the way. A considerable portion of the viaduct is a reinforced concrete structure.

North of the end of the bridge are being laid

out some extensive yards. There will be 15 4,500-ft. tracks, besides shorter ones and cross-over tracks, making a total of about 20 miles. The ground will be graded to the grade of the track on the bridge.

At about 6,000 ft. from the bridge is crossed Columbia Slough. A 159-ft. truss span and a 70-ft. plate girder span are here used, with abutments on pile foundations. At the foot of the hill is made an overhead crossing of the St. John's extension of the O. R. & N. Ry. (mentioned in Eng. News of May 16, 1907). The maximum grade of 0.2% is used for a mile before reaching here, rendered necessary to reach the proper clearance height above the other road. At this point the grade reduces to 0.00%, which continues on to the northeast end of the Willamette Bridge, a distance of over 1½ miles more. These grades are the only ones against westbound trains on the entire line, and the rise is only about 15 ft.

PENINSULA CUT.—Immediately beyond the O. R. & N. crossing begins the big cut through the broad ridge or bench that forms the summit of the "Peninsula," as the strip of land lying between the Columbia and Willamette is called. This ridge slopes gradually to the Columbia Bottoms, but on the Willamette side it breaks off abruptly to the river below. It is composed entirely of sand and fine gravel, except for a few feet of clayey material at the surface. Entering the cut the surface rises for the first 4,500 ft., then flattens out and gives a cut of 84 to 91 ft. for about 2,000 ft. more, when it runs out on the steep slope facing the Willamette. The excavation has a bed width of 38 ft., slopes of 1½ to 1, and a maximum width of over 300 ft. The length is 6,740 ft. and the yardage about 2,250,000. It lies entirely within the city limits of Portland, except for a short distance where it crosses the south corner of the small city of St. Johns.

Material from the cut was used in the fill across the Columbia River bottoms, over a mile long. It was hauled out in dump cars on a track on the center line of the roadbed, and a spreader was used to spread it out to the 32 ft. top width required.

HYDRAULIC EXCAVATION.—Emerging from the big cut at the southwest end, the track crosses over that of the O. R. & N. Ry. leading to St. Johns. Here a big fill begins, which continues out into the Willamette where there is as much as 10 to 15 ft. depth of water at the very lowest stages, until it reaches the channel of the river. Here begins the bridge, at a distance of 1,500 ft. from end of the cut, and the grade (subgrade) is about 60 ft. above extreme low water, and 15 ft. higher than the grade of the Columbia or Vancouver Bridge. The fill is being made of material from the end of the big cut. The hydraulic method of excavation is here used, the sluiced material being conveyed by flumes out to make the fill. As the river bed and flat which are the foundation of the fill are very soft and yielding, the foundation has greatly settled, resulting in upheaving of the soft bed on either side, so that the amount of material required has been greatly in excess of that indicated by the cross-sections (about 300,000 cu. yds.). In making the fill it settled very fast, at one time over 10 ft. in one night.

The hydraulic method of excavating would seem to be well adapted for this place, one of the main advantages being in avoiding the excessive height of trestle that would be required for making the fill over the soft bed of the river by other methods. The water required is pumped by a steam plant on the bank of the river through an 8-in. pipe. It supplies two hydraulic "Giants," besides which an additional pump delivers a stream at the head of the sluice-flume to give a sufficient sluicing volume. As the flume is laid on a grade of about 5%, the depth to which the cut is hydraulicked is less than the total depth required, depending upon distance from the fill, and the remainder of it will have to be excavated by some other method. The work is being done by Lyon & Co., subcontractors.

Crossing the Willamette Bridge, which is 1,610 ft. long, the line turns to the left by a 4° curve of nearly 90° and follows up the Willamette to a connection with the Northern Pacific line from Puget Sound, at a point about 1¾ miles outside of the Portland Union Depot. As showing the radical allowance made for high-water stages in the rivers, it may here be stated that the grade at the Union Depot is 33 ft. below that at the Willamette Bridge and 18 ft. below that of the Vancouver Bridge, although both are downstream from Portland. However, as during the 1894 flood the tracks at the Union Depot were 6 ft. under water they cannot be taken as governing, though such a flood might not occur twice during a century.

Tunnel Through Rock Knoll at Drano.

Tunnel Near Plymouth.

TUNNELS ON PORTLAND & SEATTLE RY.

TRACK AND BRIDGES.—The track is of 85-lb. rails on 7 × 9-in. × 8-ft. ties laid 3,200 to the mile. The rails are of a section originated by the Great Northern Ry., and differ from the M. Am. Soc. C. E. section in having the rail head much more rounded. The rails are laid on tie plates of the P. & S. Co.'s own make. The Wolhaupter patent joint is used. The same section of rail is used for guard rails on bridges. The entire line is being ballasted with 9 ins. of ballast under the ties.

The Northern Pacific Ry. standards are used in design of bridges, the live load being as follows: Two locomotives of 188.5 tons each followed by a uniform load of 5,000 lbs. per lin. ft. Each locomotive is 57 ft. long over all, and it has 104,000 lbs. on drivers on a 15-ft. wheelbase.

GENERAL.—It is believed that no other road in the United States, even where the conditions for easy construction are very much more favorable, has such light curves and grades for such a length as this one. The fact that there are no adverse grades at all between Kennewick and Vancouver for westbound trains will allow trains of enormous weight to be hauled in this direction. The exceedingly rigid requirements and high standards used in construction, applied to a country of the rugged character traversed by this road, have resulted in very costly work. No expense has been spared to make everything of the best, and the needs and more rigid standards of the future in the railway world have been anticipated for many years.

The great scarcity and high price of labor and materials during the past two years have made the construction very much more expensive than under normal conditions. For many miles of a stretch the cost will average over $100,000 per mile, and sometimes reach $150,000, without any structures of magnitude included. There have been employed, on an average, about 5,000 men on construction of the road.

The Portland & Seattle Ry. is what is known as a "Hill road," having been built by the same interests that own the Northern Pacific and Great Northern railways. The leading spirit, Mr. Jas. J. Hill, who has been so prominently identified with the railway building and development of the Northwest, says that the new road is the best railroad in the world, without exception. In the rigid standards adopted in construction and in the splendid roadbed secured, this would seem to be true.

The line between Kennewick and Vancouver was opened in January. As the bridges across the Columbia and Willamette will not be completed until well along in 1908, the road cannot be operated any further westward at present than Vancouver. From here connection is made with Portland by sending trains over a branch of the Northern Pacific Ry. down the right bank of the Columbia to Kalama, on the main line from Puget Sound, whence they are ferried across the river to the Oregon side and run up to Portland the same as other Northern Pacific trains.

The new railway has been built under the supervision of the Chief Engineer, Mr. Nelson D. Miller, a veteran of forty years' experience in the construction of railways. For data from which this article has been prepared, the writer is indebted to Mr. Miller and to the Assistant Engineers whose names have already been mentioned.

Besides the Kennewick line the P. & S. Ry. Co. is building a line from Pasco (across the Columbia River from Kennewick) to Spokane, which will be a great improvement over the Northern Pacific line between those points, and will give a modern road that far east for the Hill system. This may not be completed for another year.

TRADE AND INDUSTRY in the United States during 1907 exceeded all previous records, notwithstanding the financial depression which prevailed during the last quarter of the year. The Bureau of Statistics on Feb. 7 made public a table of summaries showing principal commercial movements in 1906 and 1907, part of which we reproduce as follows:

	1906.	1907.
Total shipments by lake, net tons	75,609,648	83,387,919
Total shipments of iron ore, gross tons	36,872,508	40,727,972
Total shipments of coal, net tons	17,575,917	19,388,414
Total shipments of grain, exclusive of flaxseed, bushels.	145,376,536	144,136,281
Total vessel tonnage on Great Lakes cleared in domestic trade, net tons reg.	94,094,316	99,106,409
Total freight passed through the Sault Ste Marie canals, net tons	51,751,080	58,217,214
Total vessel tonnage of the Sault Ste Marie canals, net tons reg.	41,098,324	44,087,974
Freight tonnage passing through the Detroit River, net tons	60,578,155	67,292,504
Grain and flour receipts at 4 Atlantic ports, bushels	245,200,577	258,896,435
Grain receipts at 15 primary markets, bushels	798,521,585	835,277,291
Coal and coke shipments over 7 eastern railroads, tons	125,563,645	140,174,348
Coastwise coal shipments from 5 Atlantic ports, gross tons	38,782,320	44,370,287
Total anthracite coal shipments, gross tons	55,647,296	66,671,149
Connellsville coke production, net tons	19,909,165	19,716,273
Production of anthracite and coke pig iron, gross tons...	24,808,384	25,315,287
Yellow-pine lumber shipments from 8 Southern States, M ft	3,354,681	3,628,256
Lumber shipments by lake, M ft.	1,807,570	1,380,284
Redwood lumber shipments from upper California, M ft.	409,702	427,515
Pine and fir arrivals at California points, M ft.	1,192,122	1,315,382
Building operations, value, dollars	667,032,499	580,468,196
Number of cars handled by 24 car service associations	29,709,976	31,384,708

DESIGN AND CONSTRUCTION OF AUTOMATIC CAR SYSTEMS.

By CHAS. J. STEFFENS,* M. Am. Inst. M. E.

When it is necessary to unload coal, gravel or similar materials from vessels and to discharge this material to storage piles or bins within 500 ft. of the unloading point, there is probably no system of greater economy than one in which an automatic dumping car is used in conjunction with a hoist fitted with either a clam-shell bucket or an ordinary hoisting tub. The use of this system for handling materials has developed and extended until it is now to be found in successful operation in almost every country.

Among its advantages may be noted (1) the simplicity of construction, there being no complicated mechanism to care for; (2) the low cost of installation, the car and its necessary attachments costing about $500, and (3) the economy of its operation requiring, as it does, the services of but one man at the loading end.

As ordinarily arranged, the plant consists of (1) a hoist located at the bulkhead, (2) a hopper into which the hoist discharges, located above the loading point of the automatic car, and (3) the automatic car system. If tubs are used for hoisting, the hopper may be dispensed with and the contents of the tub discharged directly into the car. Where a hopper is used, it is generally made about 10 × 12 ft. on top, and of such size and construction on the bottom as to allow for a 24 × 24-in. duplex cut-off valve being attached to the frame, as shown in Fig. 4. The valve under the hopper should be approximately 5 ft. from the base of rail so as to provide for a proper discharge to the car, and on the water side the hopper should be about 7 ft. in height. In order that the material may not be thrown over the back of the hopper when a clam-shell bucket is used, the back is made higher than the front, the angle of the side to the horizontal being about 30°.

The proper location and arrangement for a mast and gaff to operate with either a clam-shell bucket or a hoisting tub is not a difficult matter, but many are so poorly arranged as to give but little satisfaction to their owners. The mast should be located as close to the line of bulkhead as possible, so that the arc through which the gaff passes when swinging from the loading point above the boats to the point of discharge above the hopper will be reduced to a minimum. In any case this arc should not be greater than 60°. If it exceeds this, not only will time be lost in swinging the gaff, but in addition the hoisting ropes will not accomplish this movement of the gaff with the gradual and even motion so essential to successful operation. When using a clam-shell bucket the hoisting ropes lead from the sheaves at the boom point to sheaves located one on each end of the cross tree. The cross tree may be placed on either the mast or the boom, as may seem preferable. From these blocks the ropes lead down to sheaves, spaced about 5 ft. apart and secured to the dock near the base of the mast. By winding more rapidly on one drum than on the other, the engineer is enabled to swing the boom in either direction at will. When a tub hoist is used there is, of course, only one rope leading from the boom to the engine, and the arrangement at best will cause the gaff to swing either in over the hopper, or out over the boat. It cannot be arranged to swing both ways, so a guide rope is attached to the boom and the man in the boat or on the trestle pulls the boom in or out as the case may be. It can be arranged to swing in either way by placing the dock block at the foot of the mast at such a position that when the block at the heel of the boom is directly over it, the bucket is over either the hopper or the boat. With clam-shell buckets it is customary to permanently fix the boom-support lines, in which case the boom cannot be raised or lowered. Where tubs are used for hoisting, the boom or gaff usually has a block at the point and another at the mast head. Through these blocks is carried a heavy manila rope which is then fastened to a cleat at the side of the mast to permit of the boom being raised or lowered. The most satisfactory service is probably obtained when the mast is set about 30 ft. from the center of the hopper or other discharging point and from 3 to 5 ft. from the bulkhead.

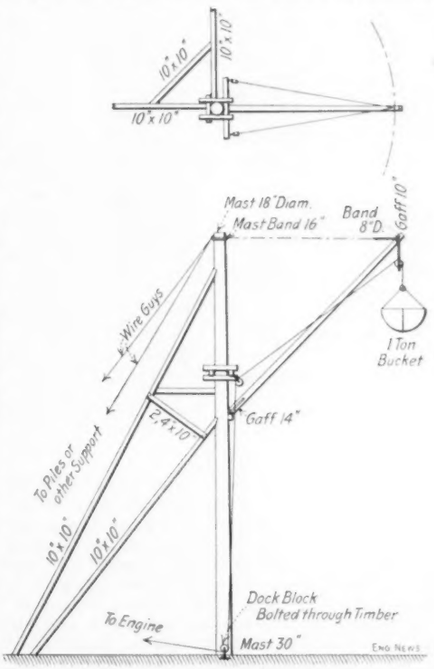


Fig. 1. Unloading-Derrick Rig, One-Ton Capacity, for Automatic Car Systems.

Fig. 1 shows the arrangement of a rig used in connection with a clam-shell bucket of one ton capacity. The mast should be of such height that the distance from the top of the mast to the hopper will be at least 15 ft. In setting the gaff, the end from which the bucket is suspended is usually placed about on a level with the top of the mast and the gaff should be set at an angle of from 45° to 60° to the horizontal.

Wire guys should extend from the top of the mast and should be firmly secured to piles or other suitable foundation, and stiff legs should also be provided unless it is possible to arrange for bracing the mast in some other manner. If wire guys alone are used, and the stiff legs omitted, it will be found that until the moment when the bucket discharges its contents, these guys are taut, but as the load is discharged by the bucket the stress at the top of the mast is removed and the mast springs back. It is in order to prevent this springing and consequent swaying of the mast, and also to brace the mast where it takes the load from the gaff, that stiff legs are required.

The dimensions given in Fig. 1 are suitable for use in connection with a one-ton bucket. If a hoisting tub be used, the rig might be made lighter, depending upon the size of the tubs. Most owners, however, who desire to install a system of this character prefer to have the mast and gaff of sufficient strength so as to provide for the possible future installation of an automatic bucket, even though a hoisting tub may be used at first.

The wire rope for hoisting should be both strong and flexible; six-strand cast steel hoisting rope, with 19 wires to the strand and having a hemp center, is ordinarily used. For the guys a cast steel haulage rope (which is strong though not particularly flexible) having six strands, with seven wires to the strand, will prove satisfactory. These should be galvanized and provided with galvanized iron turnbuckles so that any slack may be taken up readily. Galvanizing the hoisting rope is an unnecessary expense, as the bending of this rope when passing over the sheaves soon wears off the galvanizing.

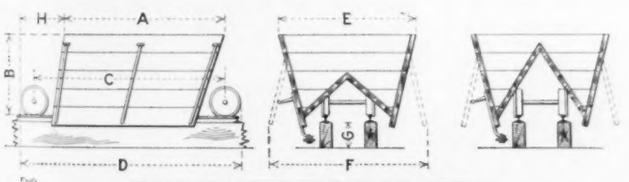
The fittings required for the rig with a clam-shell bucket, as shown in the illustration, are as follows:

One swivel gaff fitting, with mast band.
One 16-in. triple-link band for top of mast.
One 8-in. double-link band for point of boom.
One 12-in. double, wire rope, steel-shell block for point of boom.
Two 12-in. single, wire rope, steel-shell blocks with swivel for cross tree on mast.
Two 12-in. single, wire rope, steel-shell dock blocks with swivel ball connections.

Fittings for a similar rig where hoisting tubs are used would be as follows:

One swivel gaff fitting, with mast band.
One 14-in. diam. triple-link band for top of mast.
One 8-in. double-link band for point of boom.
One 10-in. single-link band for heel of boom.
One iron cleat for manila rope.
Two 10-in. double, steel-shell, manila rope blocks for gaff support lines.
Two 12-in. single, wire-rope, steel-shell blocks for hoisting lines.
One 12-in. single, wire-rope, steel-shell dock block with swivel ball connections.
One swivel hoist hook with guide sheaves.

The automatic car runs along an inclined track; being loaded at the high end, running down the incline by gravity, and discharging at any predetermined location. During its trip down the incline, the loaded car raises a counterweight attached to a wire cable which the car engages as it passes along. After discharging its load, the car becomes lighter than the counterweight, the weight falls back to its original position and



Tons	A	B	C	D	E	F	G	H	Gage
1	60¼"	30⅝"	70"	84"	5'2"	9'5"	12"	2'2"	21"
2	5'10"	37"	70"	84"	5'11"	9'6"	12"	2'3"	21"

FIG. 2. GENERAL DIMENSIONS AND ARRANGEMENT OF DISCHARGING DEVICE OF AUTOMATIC CARS.

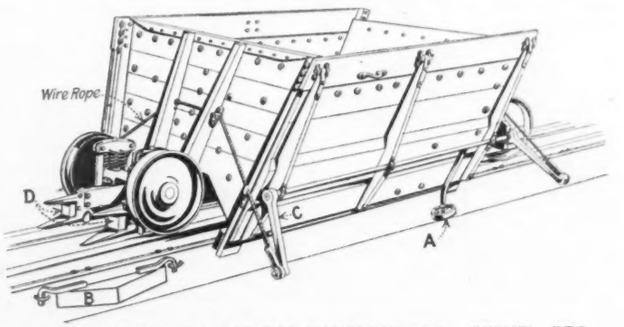


FIG. 3. AUTOMATIC CAR FOR HANDLING COAL, GRAVEL, ETC.

*Manager, Guarantee Construction Co., 90 West St., New York City.

the energy thus released is utilized to return the car to its loading point.

Cars of two sizes are constructed, one-ton and two-ton. However a one-ton capacity car is generally used, as the heavier counterweight and consequent vibration of the trestle due to a two-ton car is, in many cases, objectionable. With a car of one-ton capacity and a run of 300 ft. from the point of loading to the point of discharge, a system of this type will handle from 50 to 60 tons per hr.

Because of the high velocity at which these cars operate and the heavy service required of them, it is essential that they be constructed in the strongest possible manner, and of none but the best material. Most manufacturers construct them of oak, the joints being painted before assembling, and the various members secured by screws so that there are no nails to work loose while the car is in operation. The inside is lined with sheet iron 3-16-in. thick, and the construction of the bottom is as shown in Fig. 2. The angle which the bottom makes with the horizontal is fixed by the character of the material to be handled, being steep enough in any case to provide for the rapid and almost instantaneous discharge of the contents of the car.

The sides are hinged at the top as shown in Fig. 3, both sides being operated by the same lever so that one cannot remain closed while the other is open. Should this occur, it will readily be seen that the load would be discharged from one-half of the car only, and the load remaining in the other half would throw the center of gravity so far over that on its return to the loading end the car would probably fall from the trestle.

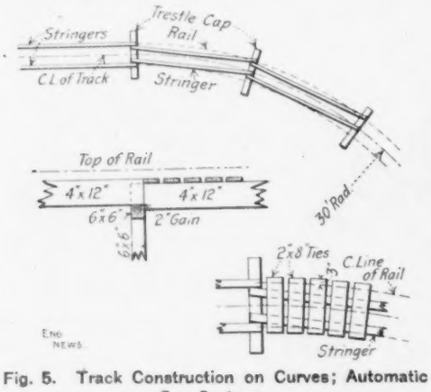


Fig. 5. Track Construction on Curves; Automatic Car Systems.

Cars of one-ton capacity, when constructed of wood and lined with steel, weigh about 1,100 lbs., and in calculating for clearance it should be noted that, after discharging its load, the doors do not close but remain open until closed by the operator at the loading point. The dimensions given in Fig. 2 may be used for calculating clearances of the one and two-ton standard cars.

In operation, the wheel marked "A" in Fig. 3 strikes the tripping block marked "B." This forces out the lever, to which "A" is attached, a sufficient distance to move lever "C" and raise it so that the wire rope, connecting the two doors, and which is slightly below the level of the side rod on the doors when they are closed, is, by the movement of the lever, brought above this level. The pressure of the material in the car will then force the doors open, so that it will discharge. At the forward end of the car are two prongs marked "D." As the car rolls down the track these prongs engage block "E," Fig. 4, which is attached to the cable operating the counterweight, and as the car by its momentum moves the block along it raises the weight.

The arrangement for the wire cable which operates the counterweight is shown in Fig. 4. The cable is secured to the trestle at "F," and from this point passes around sheave "G," from which the weight is suspended, continuing around sheaves "H" and "J" back to and around the second groove of sheave "G," and is again secured to the trestle at "K."

The sheave "G," or the "triangle sheave," as it is called, is constructed as illustrated, so that it will roll along on the iron guides shown on the cross section of the triangle track. The total maximum distance of travel for this sheave is about 17 ft., so in order to raise the weight and thus store the requisite energy for the return of the car, the forward prongs, shown in Fig. 3, must engage the cross bar about 10 or 12 ft. before the tripping block is struck and the car discharged. The weight is raised to its maximum only when it is necessary to discharge the load at the extreme end of the trestle and return the car from that point. It is customary when starting the operation of a new plant to make a few tests in order to ascertain at what point the cross bar should be set in order to return the car from the various points of discharge. This point, once located, is marked on the stringer which carries the rail, and the cross bar, which is clamped to the cable, may then be attached at the proper point for any of the various discharging locations.

The tripping block is provided with a hook on each end, these hooks allowing it to hang from screw eyes, located along the rail stringer, as shown in Fig. 3.

From the foregoing it will be seen that the cars cannot be discharged and automatically returned at a point less than about 10 ft. from sheave J, but may be satisfactorily operated to discharge and return from any position between this point and sheave G.

The rails in general use are 12-lb., 21-in. gage, the gage being to the outside of rail. They are connected by fish-plates.

The trestles are usually constructed of long leaf merchantable yellow pine and may be supported by concrete piers, mud sills or piles. Where the ground is firm, mud sills are used, but if a high class of construction is desired the foundation should be either of concrete or, in case of marsh land, piles. The objection to mud sills is that in winter the frost will heave the ground and thus throw the trestle out of line. Concrete piers should be carried at least 3 ft. below grade to secure a footing below the frost

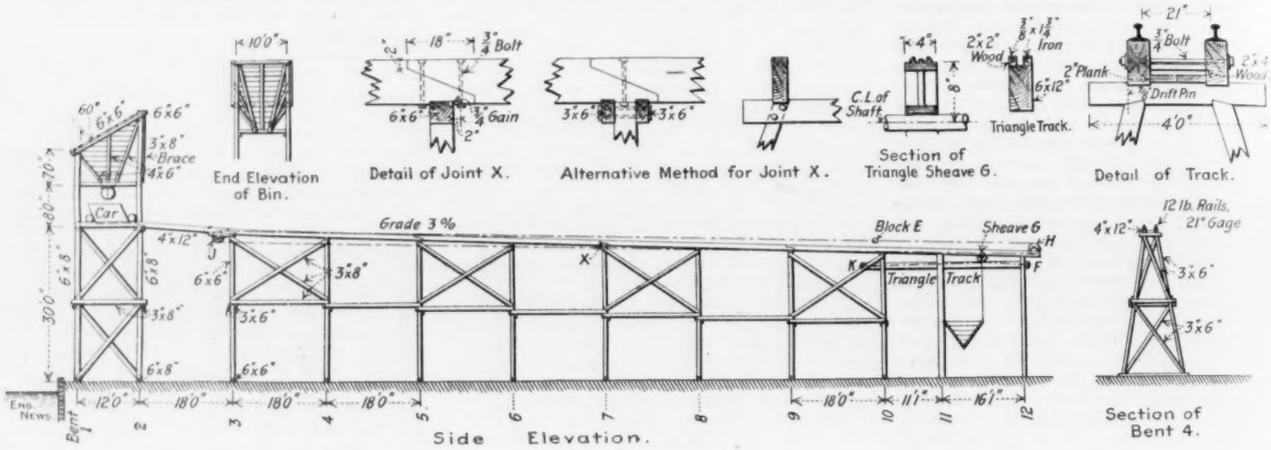
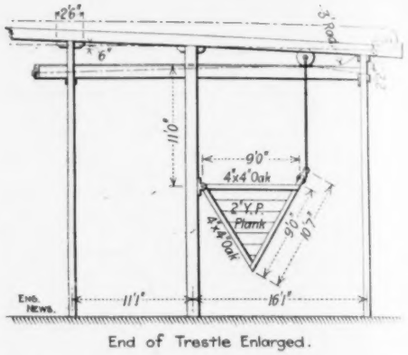


FIG. 4. A TRESTLE DESIGN FOR AUTOMATIC CAR SYSTEMS.



End of Trestle Enlarged.

level. A typical cross section of the trestle is shown in Fig. 4. The posts are placed with a batter of from 2 to 3 ins. per ft. of height, and are secured to the sills and caps by a dowel or a drift pin in addition to which they are gained to a depth of 2 ins. For trestles up to 30 ft. in height the posts are 6 × 6 ins. and the braces and cross ties are 3 × 6 ins. Caps and sills are either 6 × 6 or 6 × 8 ins., and alternate bents are cross braced above the tie with 3 × 6-in. braces. All of the timbers should be securely bolted together with ¾-in. through bolts and furnished with cast-iron washers under the head and nut of the bolt.

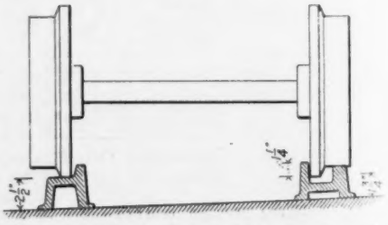


Fig. 6. Special Rails for Track Curves of an Automatic Car System.

Bents are spaced from 18 to 20 ft. centers, except where the "triangle" is located. The spacing and construction at this point is shown in the illustration Fig. 4. It is not necessary to locate the triangle where shown, as it may be placed anywhere along the line of the trestle. The stringers required for a one-ton car with bents spaced 20 ft. apart are 4 × 12 ins., and these have a footwalk between them. This walk is constructed of 2-in. plank laid from

cap to cap of the bents and supported at intermediate points by 2 × 10-in. plank secured by bolts or lag screws underneath the 2 × 12-in. stringers as shown. The wire cable slides along on these plank when the car engages the cross bar. In order to prevent the stringers from spreading or drawing together, and thus changing the gage of the rails, bolts are run through from side to side at intervals of about 10 ft. and under or at the side of the bolt is placed a 4 × 4-in. spacer which is forced firmly into its position.

Where it is necessary to use a curve in the track, the curve should be located at the loading end, and should have a minimum radius of 30 ft. Sheaves should in this case be located beyond the end of the curved part of the track, and it should be noted that cars cannot be discharged and automatically returned until they reach a point about 10 ft. beyond this sheave, as before stated. The rope operating the counterweight should have a straight run from end to end, so that no more than one curve in the track (and that at the loading end and beyond the last sheave) should be used.

Where a curve is placed in the track the construction varies from that already described. If standard rails are used for the curve, as well as for straight track, the rails are secured to cross ties and the stringers supporting these ties are so located that the ties do not project more than 3 ins. beyond the center of the rail at any point. This is necessary in order that the sides of the car, which extend below the base of the rail, may clear. It is customary to gain the stringer at the point where it is secured to the cap of the trestle in order to bring the top of the ties level with the top of the stringer which carry the straight track. The outer rail should be about 2 ins. higher than the inner rail on the curve, and this is gained by elevation blocks placed on top of the ties. This construction is illustrated in Fig. 5.

The only objection to this method is the danger of a car when running at high speed, jumping the track. When passing around a curve the only guard against this is the flange of the wheel, which is usually ½-in. Some manufacturers, in order to insure the safety of cars under these conditions and also to provide for rounding the curve with ease, furnish special rails for use on curves, as illustrated in Fig. 6. The outer wheel, as may be seen, runs on the flange while the inner wheel runs on the tread. This practically gives the outer wheel a greater diameter and the depth of the flange is in proportion to the difference in length of the two rails so that cars operated in this way pass around a curve with but little resistance.

That part of the inner rail against which the flange of the wheel presses is made high in order to act as a guard. The distance from the bottom of the flange to the top of the guard on this rail is usually about 1¼ ins. It will be noted from Fig. 3 that the flanges of the wheels are located outside of the rails. However, where the special curve rails are used, the flange is placed on the inside of the rail, as shown in Fig. 6. This is necessary in order to provide for their running on the special curve track described above. The inclination of the track should be about as indicated in the illustration Fig. 4, where at the loading end is 10 ft. of horizontal track followed by 20 ft. of track which drops 16 ins. in that distance. From this point to the end of the track the grade is about 3%. This inclination may be varied slightly if circumstances make it desirable to do so.

Where it is desired to pile the material over an extensive area for storage purposes, a number of tracks may start from the same loading point and be supplied by the same hoist. The tracks are spread out in a fan shape, curves of 30-ft. radius being installed at the loading end. Another method is to use for hoisting a traveling tower instead of a mast and gaff. Connected to this tower and traveling with it is a bridge which extends back from the bulkhead and carries the automatic car system. One plant of this character, located at Ludwigshafen, Germany, has a bridge which spans 328 ft. and the tower and bridge travel along the bulkhead for 1,000 ft. In this way an exceedingly large ground storage is secured at a minimum expense.

FIG. 1. OLD BOW-STRING TRUSS IN WASHINGTON, D. C.

FIG. 4. 110-FT. PLATE-GIRDER HIGHWAY BRIDGE, WASHINGTON, D. C.

FIG. 2. ACTION OF RUST ON COVER PLATE OF UPPER CHORD, OLD BOW-STRING TRUSS.

A PLATE-GIRDER BRIDGE REPLACING A BOWSTRING TRUSS IN WASHINGTON, D. C.

By W. J. DOUGLAS,* M. Am. Soc. C. E.

There has recently been erected in the city of Washington a plate-girder bridge on the line of K St. across the lower portion of Rock Creek where that stream is used as the river entrance of the Chesapeake & Ohio canal. The bridge consists of three plate girders, each 110 ft. long and 7 ft. 6 ins. deep, spaced so as to give two 13-ft. roadways and two cantilevered 6-ft. sidewalks. Although the new bridge has nothing to distinguish it other than the large dimensions of the girders, certain details of the abutments, the transportation of the girders to the site and the old bridge spanning the creek at this point are matters of interest.

The new bridge replaces an old two-truss through bow-string bridge which was erected about 1840. This old bridge, Fig. 1, had a top chord of two 7-in. I-beams, connected on their tops by a ¼-in. plate with a width varying from 16 ins. at the crown to 30 ins. at the abutments. This plate was riveted to the beams about every 14 ins. with ½-in. rivets. In the close view shown in Fig. 2, it will be noticed that rust had penetrated between the beams and the plate and buckled the latter considerably between adjoining rivets.

Originally the only compression member of this old bridge was the top chord, but about fifteen years ago I-beams were placed alongside of the vertical tension rods with the idea of cutting down the vibration of the bridge, which was very great. This expedient was partially successful, but up to the time it was demolished it was the most shaky bridge the writer has ever been on.

The old bridge was practically of the same length as the new one, 110 ft. The only sway bracing consisted of three transverse I-beam struts, one at the center of the span and the other two about 10 ft. from the center. In spite of its weakness and extraordinary vibration, it carried for years the heaviest travel of any bridge in the District of Columbia, excepting those carrying street cars. About seven years ago inspection showed that the floor beams supporting the wooden stringers were suspended from the bottom chord by means of wrought iron hangers which supported the floor beams by a single bolt passing through the web. Many of the holes around these bolts had become enlarged as much as ¼-in. The writer has often been surprised with the remarkable toughness of bridge material, but never has he seen a case in practice where a single bolt had been subjected to as much rough usage. This defect was relieved by installing additional hangers passing under the flange of the beams.

Before designing new abutments, careful inspection was made of the existing abutments with the idea of utilizing as much of these old abutments as possible. The old abutments above the surface of the ground consisted of second-

*Engineer of Bridges, District of Columbia.

class masonry laid up in natural cement mortar, and were in very good condition. Inspection of the foundations was also made by digging test pits alongside of the old abutments and carrying these test pits down to the foundation bed. Inspection and record showed that in about 1800 there had been a low level bridge at this point. The low level bridge had at least two piers which were built of small one-man rubble (coursed stone) resting on 6-in. piles. The original structure must have been 4 or 5 ft. above the creek level, and of course was built before the creek had been used as a canal. In about 1840, when the Chesapeake and Ohio Canal was built, new masonry abutments were built on these old piers to an elevation of about 12 ft. higher than the old one. These abutments were built with wing walls, which extended beyond the substructure of the old bridge. It is probable that the superstructure of this second bridge was a wood and iron truss, although there were no records to approve or disapprove this. In 1868 the bow-string bridge just described was built and the only apparent change in the masonry was that it was raised about 2 ft. to meet the change in grade. After the inspection, it was decided best to jacket all of this old masonry with about 2 ft. 6 ins. of concrete, resting on new piles driven in front and around the old masonry piles just described. The corners of this jacketing concrete were reinforced with steel rods, and the new concrete was doweled in the old masonry by removing about one-sixth of the facing of the old walls. The old piles were in sound condition excepting that the sap wood of a few was rotten. Fig. 3 shows, diagrammatically, the numerous changes in the abutment.

FIG. 5. HAULING A 32-TON PLATE-GIRDER THROUGH THE STREETS OF WASHINGTON.

The work of jacketing the abutments of the new bridge was executed in winter because it was practicable to drain out the canal water at this time of year, which decreased the cost of pumping in the foundation pits, and as there is no travel on the canal at this time of year it was possible to carry on the work without looking out for the maintenance of canal travel; furthermore it was thought best to build the entire bridge in winter and spring because K St. is a river street and is used more in summer and fall than at other times of the year. To have erected the bridge and at the same time maintained travel would have cost the contractor about $2,500 more than the contract price.

The contractor was required to rivet up the girders complete at the shop in order to get the best riveting in the heavy flange sections. After building they were loaded on three cars and were unloaded at Washington by means of a 100-ton crane, at which time they were placed upon two strong wagons, each wagon being placed about 15 or 18 ft. from the ends of the girders. The center girder weighed 37 tons and the two outside girders weighed 32 tons each. Each girder was hauled on two wagons to the site of the work, a distance of about 3½ miles, the contractor using 22 horses for this purpose. The city would not issue a permit for hauling the girders except between the hours of midnight and 5 a. m., as it was thought that these large girders might be the cause of a serious street car tie-up in case of a breakdown on a car track during the day time. It was necessary to cross 14 car tracks before reaching the bridge site. The grades were, as a rule, less than 3%, excepting a short rampway of about 100 ft. coming from the Baltimore & Ohio freight yards, which has a grade of about 5%. The first girder got away on this rampway and came very nearly causing trouble, due to one of the laborers trying to chock a single wheel while the girder was moving rapidly down the grade. After leaving the rampway they managed to get about five blocks without any trouble, but at this point in crossing a street railway track the front wheels of the front wagon were skewed around, the girder being carried over to the sidewalk, rooting up a 6-in. tree and putting one of the wagons out of commission for that night.

It took four days to haul the first girder across town. The second girder could have been taken across in less time but there was a light snow and freeze which tied up the girders in the fashionable section for four or five days, causing more or less comment due to its interference with social functions. The third girder was hauled across the city in one night without any trouble. The hauling contractor paid the following bill to the city for damages done in hauling the girders:

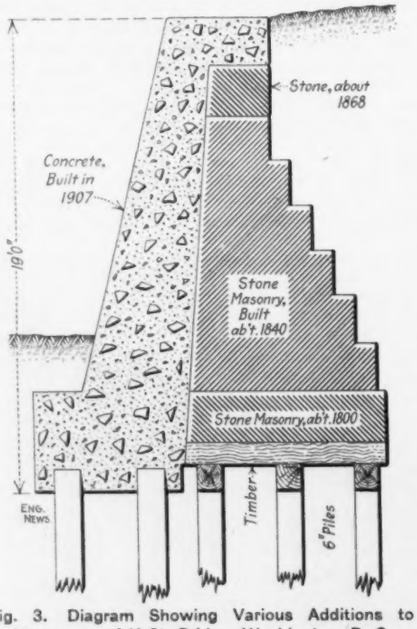


Fig. 3. Diagram Showing Various Additions to Abutments of K St. Bridge, Washington, D. C.

Estimated cost to repair asphalt pavements	$41.44
Cost to reset curb	2.00
Cost to replace manhole frames, covers and material	14.60
Estimated cost of repairing asphalt around manholes	6.00
Cost to replace tree	10.00
	$74.04
Fixed charges 5%	3.70
Total	$77.74

He also paid $100 in demurrage. He received $600 for hauling the girders, which is approximately $6 a ton, or about $4 more per ton than if the girders had been shipped to the site of the work in more easily handled sections.

The girders were hauled on the wagons in a flat position. When they arrived at the bridge site they were blocked up from the wagons on timber cribs and were afterwards jacked down from these timber cribs to the tops of the small platform cars which were placed on a narrow gage track, and on this track they were hauled across a timber trestle to approximately their final position. They were then lifted into a vertical position by means of two construction derricks, one on each abutment, and were then lowered by jacks into their final position.

Fig. 4 shows the completed bridge and Fig. 5 is a view showing one of the outer girders being hauled through the streets of Washington.

The contractor was Mr. James Overn, C. E.; the contract price $32,500 for the bridge proper, while the work outside of the original contract and the engineering make the total cost $38,000. The work was designed and constructed under the supervision of Col. John Biddle, U. S. A., and Capt. J. J. Morrow, U. S. A., with Mr. W. J. Douglas, Engineer of Bridges, and Mr. W. P. Darwin, Ass't Engineer of Bridges, in immediate charge.

SWAMP AND OVERFLOWED LAND DRAINAGE IN THE MISSISSIPPI BASIN.

By F. W. HANNA.*

There are about 40,000,000 acres of swamp and overflowed lands in the Mississippi Valley States capable of profitable reclamation, a large percentage of which drains into the Mississippi River and its tributaries. Of this amount approximately 50% lies in the Mississippi River basin below the mouth of the Ohio River; the remaining portion is quite generally distributed among the states bordering on the upper Mississippi and the lower Ohio River. The reclaimable land consists of two classes, merging more or less into one another, each of which requires different engineering construction to make it utilizable. The swamp lands proper either have no outlet or have an imperfect one and are, therefore not capable of cultivation in their native condition. The overflowed lands consist of areas along creeks and rivers having an elevation above ordinary water stages, but below flood stages. This class of lands is either intermittently cultivated or is cultivated with varying success. Much of the former class of land and practically all of the latter class have high productive possibilities, the soil of the swamp lands consisting almost wholly of decayed vegetable matter and that of the overflowed lands of rich silt deposits.

Originally a considerable percentage of what was termed prairie lands in the upper Mississippi Valley consisted of wet marsh lands. The slough was the predominating kind of marsh and exerted a marked beneficial influence on the runoff of the streams in this part of the country. These sloughs, filled the upper portions of the valleys of nearly all small streams and covered portions of the bottom lands of both the smaller and the larger creeks and rivers. These lands were in all instances covered with dense growths of coarse grass, reeds and flags growing several feet in height. The soil on which this growth flourished was composed of masses of decayed vegetation several feet in depth. This entire underlying stratum was interspersed with vegetation roots, and the upper portion having a thickness of from one to two feet was extremely porous. After each rain of consequence this porous material became saturated and the water stood several inches deep over the entire area, entangled in the thick growth of grasses. These combined conditions produced a storage reservoir some two or three feet in effective depth from which the water gradually found its way into the imperfect channel leading through the slough to the creek below. Thus these sloughs served as regulators of the storm runoff. Thousands of acres of this kind of wet land in the prairie regions of the Central West have been drained by individual and co-operative efforts.

*Engineer, U. S. Reclamation Service, Washington, D. C.

The imperfect channel of the old slough has been straightened, widened and deepened so that the surface waters are rapidly carried away. The slough has been subjected to the pasturage and consequent tramping of animals, so that the once porous layer referred to has been compacted into a comparatively impervious crust, largely preventing the original ground storage capacity. The inevitable results, therefore, of this reclamation have been greatly increased maximum and similar decreased minimum discharges of creeks and rivers. The cultivation of the soil and the consequent erosion by rainfall has also loaded each stream at flood stages with vast quantities of silt that are building up the banks on bottom lands adjacent to the channels of the streams, raising river beds to abnormal heights above the adjacent bottom lands, and often causing changes of channels from their accustomed locations. Such conditions of water stages and silt transportation are, therefore, not only menacing to valuable municipal and agricultural property along the streams, but to the navigation of the larger rivers for commercial purposes.

The beneficial effects of forests on the regulation of the flow of streams has been thoroughly demonstrated both in Europe and America. Unfortunately this regulating effect is not yet reduced to a measurable basis, and it is, therefore, necessary to discuss problems involving it in general terms. The causes of this regulation are fourfold. The canopy of the forest intercepts a large percentage of the rainfall and returns it to the atmosphere by evaporation. The forest floor, as it is called, consisting of humus, dried leaves, twigs and fallen trees greatly obstructs the flow of rainfall over the surface of the ground, giving greater opportunity for percolation and delaying its arrival at the water course. The interspersing of the soil with multitudes of roots also aids in carrying the water to ground storage, where it finds its way into the water courses at a much later date. Finally, the transpiration of the trees disposes of large quantities of water by returning it to the atmosphere, thus decreasing the amount of precipitation to be disposed of as run-off. Originally, practically the whole Ohio River drainage area was covered by forests, as was the major portion of the upper Mississippi drainage. At the present time less than 40% of the drainage area of the Mississippi River above the mouth of the Missouri River and less than 50% of the drainage area of the Ohio River are covered by forests, while only a small percentage of that of the Missouri River is forested. Moreover, a considerable percentage of these forested areas is subjected to the pasturage of animals, thus disturbing natural forest conditions. These extensive changes in the forest conditions have made great and detrimental changes in the flow of the rivers draining the areas covered by the forests.

These two causes, the reduction of the forests and the reduction of the prairies, have already crowded the river channels of many of the streams tributary to the Mississippi River so that the question of their improvement and of the control of their waters is imperative to the preservation of existing institutions. They have likewise affected the Mississippi, increasing its range of stage and the amount of sediment carried by it and consequent power for evil, necessitating larger and stronger levees than would otherwise be required and more extensive and constant dredging of its channel for navigation. The question of forest reserves to prevent these evil conditions is important, and likewise, under limitations, is the question of swamp reserves. In neither line should anything be done that magnifies the bad conditions existing. In the case of the humid prairie states and of the now valuable agricultural lands once forested, it is neither possible nor desirable to return the drainage areas of the rivers to their natural state in order to regulate the flow of the water. The destruction of the natural reservoirs has been a necessity to the development of the resources of the land. In the case of the deforested areas of non-agricultural lands, the profit has been to the lumberman and not to the succeeding owner of the land. The method of lumbering has largely been one of destruction to the forest, to the land and to the stream. Reforestation of this land is in many cases impossible and in all cases a matter of years of patience and expensive hard labor. The return of streams to their natural regimens is, therefore, hardly to be expected through the return of drainage areas to their natural conditions.

It may be thought that the effects of drainage of the swamp and overflowed lands in the Mississippi drainage basin is too insignificant to affect the regimen of this river and its tributaries. When, however, it is realized that a large percentage of this land consists of overflowed bottom lands on the Mississippi River and its tributaries that act not only as reservoirs to retain the flood waters passing down the stream until they are evaporated or percolate gradually back into the river again, but also as retardants on the stream velocity, the magnitude of the effects become apparent. Overcrowded channels exist on a great majority of the rivers and small streams in question. When floods occur, the low lands act as reservoirs and the spreading of the waters holds back the flood until the waters in the lower reaches run-off. On the other hand, if the water is confined to an improved, narrowed and straightened channel, the quantity and velocity of the water flowing in the stream is greatly increased, thereby causing great quantities of water to reach the lower valley of the stream, thus inundating lands hitherto out of flood reach.

It is evident, then, that the drainage of swamp and overflowed lands on a river system may have far-reaching evil consequences unless those consequences are anticipated and prevented. This is especially true of the Mississippi River and most of its tributaries, because as a rule these streams have comparatively broad bottom lands, low banks and inadequate flood channels. The drainage of lands on any stream should be considered in connection with such protective works as may be occasioned thereby on its lower reaches. Likewise the drainage of several tributaries on a stream may necessitate the improvement of the waterway channels or the regulation of flow of the whole stream. So the reclamation of the vast areas of swamp and overflowed lands in the great Mississippi drainage basin should be considered in conjunction with a vast scheme for the control of the flow of its waters. Agricultural interests are, however, not alone in requiring the regulation and control of stream flow. The necessity exists on other grounds for the regulation of the flow of many of our rivers, and as the resources of the country are more generally and intensely developed this necessity will become more imperative. Navigation, hydraulic power plants, municipal water supplies, disposal of sewage and factory waste, protection from floods, irrigation, mining, manufacturing and interests of other natures will either individually or severally require ultimately the control of the flow of all the affecting streams.

In order to accomplish the greatest good to all interests concerned the control of stream flow will have to be obtained from two distinct classes of improvement, namely, those having a regulating and those having a guiding influence on the movement of the waters of the streams. The regulating improvements should consist of both natural and artificial means of storing water in seasons of heavy precipitation and releasing it in dry periods. For this purpose reserves should be made of the forests and of the swamp lands of uncertain agricultural value. In many cases such swamp lands, especially in Minnesota and Wisconsin, may be converted into lakes by increasing the elevation of their outlets, and many of the lakes in these states may be greatly enlarged by similar treatment, thus causing them to overflow surrounding marsh lands and otherwise increasing their storage capacities. The Ohio and Missouri rivers and their tributaries having their headwaters in the mountains should be controlled by storage reservoirs, as good reservoir sites exist on the tributaries of these two great river systems. The guiding improvements referred to consist of providing and supplementing channels of stream flow. Appropriate drainage channels should be constructed for valuable swamp lands; the channels of many creeks and small rivers should be straightened, deepened and widened; and some of the smaller streams and many of the larger rivers should be confined to definite channels by means of levees.

The plan of stream control by storage is one in which there has been considerable interest and activity for a number of years, and can be relied upon to produce general beneficial results in any scheme of improvement of the water problem in the Mississippi valley. No matter what the primary purpose of such works may be, the ultimate results will be felt beneficially along the entire lines of flow from the storage points to the Gulf of Mexico. In this line of improvement approximately 17,500,000 acres of timber land have been set aside as forest reserves by the United States and the various states interested in the Mississippi valley, mainly in the Missouri River drainage area. The U. S. Reclamation Service is now constructing for irrigation purposes four large reservoirs on the headwaters of the Missouri River system, controlling about 1,770,000 acre-feet of water and is contemplating the construction of others in the future. Within the period between 1881 and 1895 the War Department built, mainly for the benefit of navigation, five reservoirs on the headwaters of the Mississippi River system in Minnesota, controlling about 2,100,000 acre-feet of water. This branch of the government service reported at one time favorable locations for 41 reservoirs on the tributaries of the Mississippi, in Minnesota and Wisconsin, capable of storing at a reasonable cost over 4,000,000 acre-feet of water. It is to be regretted that the most economically feasible sites of this group were not either converted into storage reservoirs or withdrawn from public entry while available.

Within the last ten years great impetus has been given by the high prices of land to the construction of drainage works in the Mississippi valley, particularly in Minnesota, Iowa, Missouri, Illinois and Indiana. This work has been greatly facilitated in many of the states in this region of the country by the passage of new drainage laws, enabling the related interests to cooperate. Drainage channels opening up for agricultural purposes large areas of swamp lands have been constructed with considerable success. A large proportion of the work recently done, however, has consisted of straightening crooked stream channels and of confining creeks and rivers to existing channels by means of levees. Practically all of the straightening and improvement of channels has been done on the creeks and smaller rivers, while the levee work has been done both on the small streams and on the larger and more important rivers. Some of the work done, owing to insufficient extension of drainage districts and to lack of unitary consideration of large drainage features, has been only partially satisfactory. Naturally, the general effects of the reclamation of swamp and overflowed lands on the behavior of floods at a distance on the stream below have received no consideration by local interests.

The drainage area of the Mississipi River system is about 1,240,000 sq. mi., comprising over one-third the area of the United States. The vastness and ease of conquest of its almost endless acres of fertile hills, plains and valleys have for a long time concealed the value of its still more productive swamp and overflowed lands. Increased prices and scarcity of farm land are discovering the value and possible utility of these lands and will ultimately demand their complete reclamation. This reclamation has been shown to be intimately connected with other engineering problems of great magnitude. After the collection of much needed topographic and hydrographic data, these problems may and undoubtedly will be connectedly and systematically solved along the lines of stream control and stream guidance herein discussed.

THE RECLAMATION OF MINNESOTA'S WET LANDS.*

By GEO. A. RALPH.†

The State of Minnesota has an area of over 53,000,000 acres, over 3,000,000 acres of which is water surface. Of the land area, nearly 10,000 acres was too wet for agricultural purposes in its natural condition. More than 3,000,000 acres have already been reclaimed, and at the present rate of progress, practically all the wet lands of the State will be reclaimed in 15 years. The State is favorably situated with respect to drainage, located in three great natural drainage areas, from which the waters flow north to Hudson Bay, east to the Gulf of St. Lawrence and south to the Gulf of Mexico. The Mississippi River rises at an altitude of 1,550 ft. and leaves the State at an altitude of 724 ft. The St. Louis rises at an altitude of 2,000 ft., and flows into Lake Superior at an altitude of 602 ft. The Red River of the North rises at an altitude of 1,602 ft. and crosses the Canadian boundary at an altitude of 748 ft. More than half of the total descent of each of these streams is found in Minnesota. The surface slopes of the wet land acres are favorable for cheap and effective drainage. The best estimates obtainable place the average cost per acre (to all lands benefited) at $1.50 for the construction of all outlet ditches. Tile drainage wherever required can be put in at as low a cost as in other states.

The benefits resulting from the drainage of the swamp lands are realized as soon as the water is drained off. A tract of land owned by G. G. Hartley, of Duluth, was drained in 1906, and in 1907 a crop was grown on the land. No time was needed to reduce the wild land. Celery grown in this land this year gave a net return of $1,500 per acre; the owner expects a return of $3,000 per acre from the second crop. Mr. Hartley has over 1,000 acres of these reclaimed swamp lands under cultivation, upon which he raises grain, hay and vegetables of all kinds. The returns in all cases are very good. Numerous instances might be cited of the productiveness of these reclaimed wet lands. Each year seems to bring greater activity along this line. There are at the present time 50 large ditching machines of the floating dredge and other types at work constructing drainage ditches in the State. These machines have an average capacity of 40,000 cu. yds. per month, when the machines are all running at their full capacity.

Up to the present time over $3,000,000 has been expended by the people of Minnesota in drainage work. Of this amount $542,000 was appropriated by the State Legislature, and expended under the direction of the State Drainage Commission. The balance was expended under the direction of the several county boards, the amount being raised by direct taxation against the lands affected. The year 1908 bids fair to far exceed all former years in the amount of drainage work that will be carried out in this State. It is quite probable that at least 60 large excavating machines will be at work during the ditching season, and that nearly 2,500,000 cu. yds. per month will be excavated on drainage ditches. Tile drainage, or underdrainage, is now being carried out on an extensive scale, especially in the southern part of the State. The cost of constructing ditches in Minnesota has changed but little during the past 20 years, and has run from 6½ to 12 cts. per cu. yd. for work that could be done with excavating machines. The lowest mark, or 6½ cts. per cu. yd., was reached last year. The price that work can be done for is governed largely by the amount, character and accessibility of the job.

The most essential element in comprehensive drainage work carried out under the direction of federal, state or municipal authority, is a good drainage law: A law under which ditches can be constructed, and the burden of costs fairly and equitably distributed. A law under which all lands benefited by the construction of a ditch can be assessed for a proper share of the cost. A drainage law so framed that those who are disposed to block public improvements may be forced to obey the will of the majority, when it is exercised so as to give the greatest good to the greatest number. A law under which national, state and municipal authorities may co-operate. The present drainage laws of Minnesota are the outgrowth of numerous drainage laws enacted by different legislatures since the year 1887. The best evidence of their worth as drainage laws is the fact that we are doing a great deal of drainage work, and having very little litigation over ditch matters.

The problem of regulating and controlling the flood waters of our natural water sources is one that demands serious consideration. In Minnesota, as well as in other states, the most logical solution seems to be in conserving the floods wherever practicable on the larger streams by the construction of impounding reservoirs, and by straightening, deepening and otherwise improving the smaller channels. Many of the smaller streams in Minnesota have been improved in this way, with excellent results. By the construction of impounding reservoirs on the head waters of the Red River of the North and the Minnesota River, all damage from floods on these streams could be averted, and the benefits would far exceed the cost of the improvement.

*Abstract of a paper read at the annual meeting of the Illinois Society of Engineers and Surveyors, at Champaign, Ill., Jan. 15 to 17, 1908.

†State Drainage Engineer, St. Paul, Minn.

FIG. 1. A TRENCH EXCAVATING MACHINE OF THE WHEEL TYPE.
David W. Miller, Chicago; Inventor.

A NEW TRENCH EXCAVATING MACHINE.

Within the past few years there has been a rapid increase in the use of trench excavating machines to expedite the work and reduce the labor cost of digging trenches for water, gas, sewer and drain pipe. One of the latest of these machines has recently been built at Chicago. It is of the wheel type, and is shown in the accompanying cuts. Fig. 1 is a general view of the machine with the excavating wheel raised out of the trench. Fig. 2 is a rear view, showing the position of the buckets in the trench. This latter view also shows the conveyors for handling the excavated material. The long arm projecting to the right of the wheel, at the top, is one of the cutters. The machine is the invention of Mr. D. W. Miller, 171 LaSalle St., Chicago, and was built at the shops of the Superior Engine & Boiler Co.

The bed of the machine is supported on four wheels like those of a traction engine, and at the rear end are two booms carrying the shaft of a wheel 20 ft. in diameter. The rim of this wheel is formed of a steel channel and around it passes a link-belt driving chain. The wheel has six arms or spokes, which project beyond the rim, and each arm carries a steel bucket having a hinged bottom. The buckets are set alternately on opposite sides of the wheel, as shown in Fig. 2. In front of each bucket is a cutter arm which cuts and loosens the material ready for the bucket. The buckets cut towards the machine, and as each comes up level with the shaft, its bottom door is tripped and the load drops into a hopper at the lower end of a belt conveyor. This conveyor delivers the dirt in a pile for backfilling, or into wagons for removal. There are two conveyors, one on each side. Each hopper is hinged and is pushed forward out of the way by each bucket, falling back into position in time to receive the load from the bucket. The machine is self-propelling and its weight is always carried on solid ground ahead of the trench.

A 25-HP. vertical boiler supplies steam to a vertical engine. By means of clutches and gear-

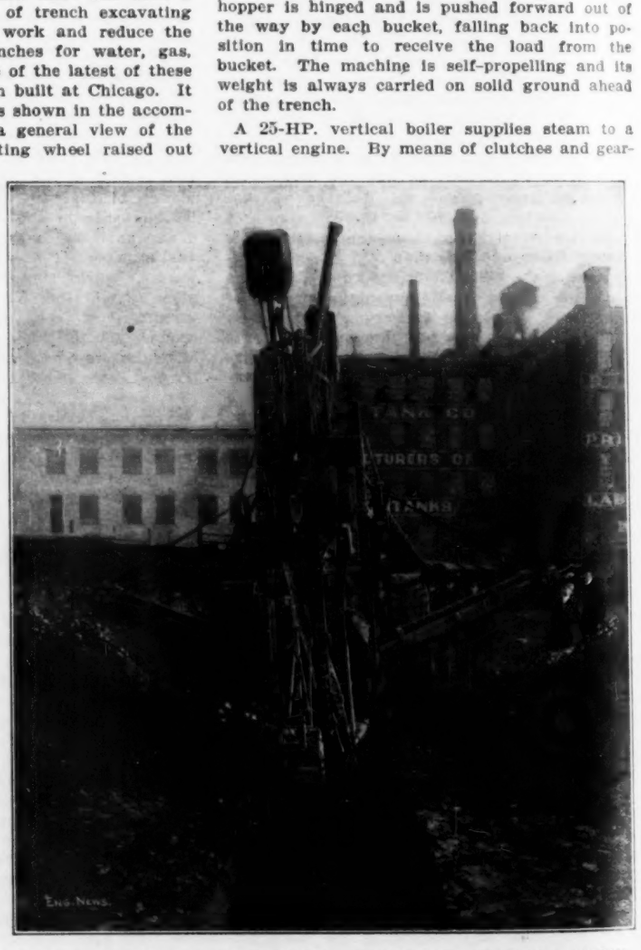


FIG. 2. REAR VIEW OF TRENCH EXCAVATING MACHINE, SHOWING THE POSITION OF THE BUCKETS AND CONVEYORS.

ing the engine drives the chain wheel of the excavator, the conveyors and the propelling machinery. The booms carrying the shaft of the wheel are guyed from a steel frame pivoted to the rear end of the bed. Steel cables passing through pulley blocks attached to the top of the frame and to the bed have their free ends wound upon drums operated by the engine. In this way the wheel can be raised clear of the ground or lowered to the required depth of excavation.

The weight of the machine is about 14 tons. It will cut to a width of 3 ft. and a depth of 10 ft., and in soft material it can form the trench with sloping sides to prevent caving. The six buckets have a combined capacity of about 1 cu. yd., and the wheel makes about five revolutions per minute. The machine can travel at a speed of five miles per hour by its own power. It can be used in excavating farm and irrigating ditches as well as for pipe trenches in streets.

THE PANAMA CANAL: A BRIEF STATEMENT OF WORK, EQUIPMENT AND FINANCES.

The Isthmian Canal Commission has just issued for general information a detailed record of Panama Canal excavation, together with a tabular summary of the main items of receipts and expenditures. We reprint this statement below in but slightly condensed form. It expresses in most compact form the statistical facts of the work at Panama under the American occupation. A graphical record of the progress of excavation is contained in the diagram reproduced herewith, also prepared by the Commission. The full circle of this diagram represents the amount of excavation which remained to be done on May 1, 1904, when the American forces succeeded the French company; as will be seen from the sectors representing work done since then, nearly one-fourth of this amount has been excavated; in figures, 20.5%. Counting on the basis of the total excavation required originally, assuming that 36,000,000 cu. yds. of French excavation are utilized under the present project, the American work is 15.9%, and the sum of the utilizable French and the American work is 38¼% of the entire work. The present monthly production, taken as two million cu. yds., represents 1¼% of the entire work and 2.03% of the excavation work still left to do.

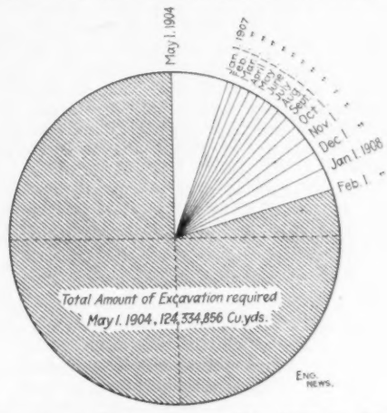
FRENCH EXCAVATION.—The amount of material excavated by the old and new Panama Canal companies was 81,548,000 cu. yds. It was estimated in the report of the Commission for 1901 that 36,689,965 cu. yds. of this amount would be useful in the main line of the new canal, to which must be added the prism excavated by the company since the date of that report, 3,510,231 cu. yds., making a total of 40,200,196 cu. yds. This amount, however, will be reduced by the submergence of the channel between Gatun and Bohio, which would have been utilized by the plan of the Commission of 1901, but is not utilized in the present project.

TOTAL EXCAVATION REQUIRED.—The following is the total estimated excavation required, May 1, 1904, based on the present working plans:

In canal prism	106,931,849	cu. yds.
Excavation for locks, regulating works and diversion channel	10,363,400	" "
Dredging entrance to old canal at Colon for wharf purposes, and to aid in construction of Gatun works; and at Panama to keep channel open to La Boca	7,039,607	" "
Total	124,334,856	" "

For purpose of comparison it may be stated that the estimated amount of excavation required in the canal prism for a sea-level canal, as recommended by the majority of the Board of Consulting Engineers, was 231,026,477 cu. yds.

AMERICAN EXCAVATION.—The amount of material excavated since American occupation is given by the following table. [The monthly figures for 1904 and 1905 are omitted. The monthly total first reached 300,000 cu. yds. in January, 1906, and never fell below that figure thereafter. In January, 1908, the month's work was over seven times as much.—Ed.]



Progress of Excavation on The Panama Canal Under the United States, as Compared with Total Excavation Required.

STEAM SHOVEL EQUIPMENT.—Thirty-two 95-ton, twenty-eight 70-ton, three 45-ton, and one 38-ton steam shovels, or a total of sixty-four steam shovels (of which three have been assigned to the Panama Railroad), are now in commission; six 95-ton, fourteen 70-ton, and seven 45-ton steam shovels are either en route or have recently been delivered, and will soon be in use; and in addition, ten 95-ton steam shovels will be delivered in the near future, making a total of 101.

FORCE EMPLOYED.—In the month of December, 1907, there were slightly over 45,000 employees on the Isthmus on the rolls of the Commission and of the Panama Railroad, about 6,000 of whom were Americans. On Dec. 31, 1907, there were actually at work 29,911 men, comprising 23,763 men for the Commission, and 6,148 (est.) for the Panama Railroad.

FINANCES.

APPROPRIATIONS FOR THE CANAL.—In addition to the $40,000,000 paid to the French company for its property and rights of all kinds on the Isthmus, and the $10,000,000 paid to the Republic of Panama for the rights granted under the treaty between that Republic and the United States, there have been appropriated by Congress the following amounts "to continue the construction of the Isthmian Canal":

Act of June 28, 1902. This act limits the amount to be thereafter appropriated to the sum of $145,000,000, of which there is appropriated thereby		$10,000,000.00
Act of Dec. 21, 1905		11,000,000.00
Act of Feb. 27, 1906		5,990,786.00
Act of June 30, 1906		25,456,415.08
Act of March 4, 1907		27,161,367.50
		$79,608,568.58
These sums included amounts to be loaned and advanced to the Panama Railroad Company to pay for the re-equipment of that company, as follows:		
Act of Feb. 27, 1906	$650,000.00	
Act of June 30, 1906	1,000,000.00	
Act of Mar. 4, 1907	1,385,000.00	
Act of March 4, 1907, to pay for the 4½ per cent. first mortgage bonds of the Panama Railroad Company	2,333,367.50	$5,333,367.50
The gross sum appropriated to date, and the divisions under the headings stated is:		
For payments to the French company and to Panama		$50,000,000.00
For loans and advances to the Panama Railroad Company		5,333,367.50
For construction of the Isthmian Canal		74,275,201.08
		$129,608,568.58

EXPENDITURES.—The following is a statement of the expenditures up to June 30, 1907:

Construction of Canal	$29,782,682.60	
Buildings	5,862,384.90	
Panama waterworks, sewers and paving	1,217,445.52	
Colon waterworks, sewers and paving	763,302.30	
Panama Railroad advances	1,826,683.50	
Total construction and engineering		$39,452,498.82
Government of the Canal Zone	1,431,151.71	
Buildings	388,101.40	
Zone highways	499,023.70	
Total civil government		2,318,276.81
Sanitation and hospitals	4,799,642.04	
Buildings	750,565.96	
Total sanitation		5,550,208.00
Miscellaneous expenditures and credits	6,422,906.41	
Deduct miscellaneous receipts and debits	5,458,779.67	
Net miscellaneous		964,126.74
Total expenditures		48,285,110.37
Balance available July 1, 1907		31,323,458.21
		$79,608,568.58

Year and month.	Culebra Division by steam shovel from canal prism. Cu. yds.	At other points by steam shovel from prism. Cu. yds.	By steam shovels outside prism. Cu. yds.	Dredging in canal prism. Cu. yds.	Dredging outside prism. Cu. yds.	Total for month and year. Cu. yds.	Totals of American excavation.
1904	243,472	.....	.....	.....	.....	243,472	243,472
1905	914,254	.....	.....	.....	884,973	1,799,227	2,042,699
1906:							
Jan.	120,990	.....	.....	.....	186,640	307,630	2,350,329
Feb.	168,410	.....	.....	.....	201,440	369,850	2,720,179
Mch.	239,178	.....	.....	.....	243,470	482,648	3,202,827
Apr.	213,177	.....	.....	.....	197,900	411,077	3,613,904
May	196,200	.....	.....	.....	177,215	373,424	3,987,328
June	212,623	.....	.....	.....	136,197	348,820	4,336,148
July	159,789	.....	.....	.....	167,400	327,189	4,663,337
Aug.	244,823	.....	.....	.....	165,930	410,753	5,074,090
Sept.	291,452	.....	.....	.....	229,320	520,772	5,594,862
Oct.	327,009	3,055	.....	.....	208,190	538,254	6,133,116
Nov.	221,642	11,517	.....	.....	156,248	389,407	6,522,523
Dec.	278,646	41,099	.....	.....	148,928	468,673	6,991,196
	2,673,948	55,671	.....	.....	2,218,878	4,948,497	
1907:							
Jan.	539,835	47,539	25,915	.....	205,810	820,099	7,811,295
Feb.	608,490	70,177	30,613	.....	203,482	912,771	8,724,066
Mar.	769,693	100,689	48,944	.....	176,464	1,095,790	9,819,856
Apr.	841,614	103,459	39,669	.....	174,744	1,159,486	10,979,342
May	662,844	70,528	28,283	.....	256,004	1,017,659	11,997,001
June	624,586	71,181	8,739	81,352	176,341	962,199	12,959,200
July	770,570	64,262	23,675	212,660	5,600	1,076,767	14,035,967
Aug.	786,866	86,662	35,857	357,454	5,127	1,271,966	15,307,933
Sept.	753,288	143,237	46,070	548,467	26,350	1,517,412	16,825,345
Oct.	826,891	210,590	47,956	766,754	22,138	1,874,329	18,699,674
Nov.	778,860	229,129	54,094	782,720	10,275	1,855,078	20,554,752
Dec.	1,006,026	312,912	89,215	777,604	14,782	2,200,539	22,755,291
	8,969,572	1,510,365	480,030	3,527,011	1,277,117	15,764,095	
Grand total..	12,901,246	1,566,036	480,030	3,527,011	4,380,968	22,755,291	
[Jan., 1908	.....	.....	.....	.....	.....	2,712,568	25,467,859]

THE TRANSPORTATION PROBLEM IN THE PORTLAND CEMENT PLANT.

By C. J. TOMLINSON.*

The American industrial condition has been one of rapid expansion and in this general increase in industries there has been none of equal magnitude which has developed with the rapidity of Portland cement. We are passing through a period of intense activity in the construction of plants for the manufacture of Portland cement. Established factories are enlarging their works or are building additional plants and engineering companies, organized to undertake such plants, are in the midst of most prosperous careers. Largely, no doubt, on account of this very rapid expansion in the industry, the plants being erected in different parts of the country show a widely varying practice in some of the most important particulars in their design. Not only is this true in the unrelated constructions, but also in plants being erected in the same locality, using the same raw materials and often being designed and erected by the same engineers.

One of the most important problems confronting an engineer undertaking the design of works to be engaged in the reduction of raw materials, is the problem of transportation, and it would seem that few industries have a transportation problem so difficult of satisfactory solution as the one presented in the modern cement plant. It is in the solution of this problem that we find the widest variation of practice in up-to-date cement plants. Many plants in operation show plainly their development from the days of wheelbarrow and shovel and hand propelled truck, and a number of the engineers engaged in this work have had their ideas molded by their experience in plants using makeshift appliances to dispense with the hand labor involved

*Neponset, Ill.

in this work. Take for illustration a plant designed for a capacity of 4,000 bbls. per day. This is not a large plant as compared with some, and will readily serve as a typical case. The quantity of raw material reduced and transported to the kilns will approximate 1,052 tons per day or 44 tons per hour, and will represent 752 tons of clinker per day or 31.3 tons per hour, to be transported to the finishing machinery, and stored, sacked and loaded for shipment. The elevation of the product during the operations involved will, in the case of a mill using a grinder finishing the material at one operation, amount to a total of 200 to 250 ft., depending on the size of the bins over the different machines. This storage space is an advantage not to be curtailed if expensive delays from trivial accidents in the different departments are to be avoided. This elevation of the material does not represent a large use of power, but it will often mean an altogether disproportionate expense account. The figures given are conservative and represent an arrangement generally used in a locality having access to a cheap fuel. The raw material will be dusty and gritty and there will be times when it will contain a sticky clay that will hang up on everything it touches until it is well on its way through the driers. It will leave the driers in a heated dusty condition that will create havoc with the journals and pins of a conveyor or elevator. This heating will be repeated as it passes through the different grinding machines and the material often leaves the kiln to be taken up at once by the elevating machinery, as a product that may well be calculated to destroy any ordinary continuous elevator or conveyor and also heat the same to a temperature that will make speedy repairs an impossibility.

The three methods of transportation in general use in such a plant as the one noted are the chain elevator and conveyor, the belt conveyor and the screw conveyor.

Though more generally a device for coal and ash handling plants, the chain elevator and conveyor has a wide use in cement plants, more particularly in some form of pivoted bucket or pan conveyor in which there is a network of chains of little pans and thousands of little wheels that require attention, have flats, jump the track at the sprockets and usually manage to run up a goodly expense account in repairs and delays. In the continuous service required of these conveyors, the small diameter and large number of the carrying wheels make them somewhat expensive to maintain, and there is a tendency to enlarge the diameter of these wheels. They should not be installed in such a manner in the kiln room that an accident to the conveyor will immediately shut down a row of kilns. This will occur when they take the clinker from revolving coolers that are directly served from the kilns or when the clinker falls directly from the kilns into the conveyor. This last arrangement is very trying on the machine, even when a small amount of water is run into the buckets with the clinker. The buckets give trouble by warping and cracking, and the heat affects the bearings in the carrying rolls and breaks the inner chain of links.

The difficulties experienced in the use of a malleable link and cast sprocket are well understood and a number of creditable attempts have been made to improve their objectionable features, but as a rule these chains are not accurate to pitch and if they were, would not stay so under the conditions imposed, and sprockets are usually designed to provide for this variation. Their wear is very rapid and an accident to one of these drives often makes it advisable to replace the entire drive as a new chain on old sprockets does not give satisfactory results, nor is it advisable to replace an accidentally broken link in a worn chain with a new link as it will not be the same pitch as the worn links. These objections are not so marked in an elevator chain using a traction wheel for a drive, but this does not imply that the elevator problem is of easy solution.

Some of the plants have the elevator and chain problem pretty well under control by using the same standard parts throughout the mill; others, when using a geared head elevator, are enclosing the gearing.

The use of the belt conveyors in cement plants has the objection of being dusty in operation and therefore requiring more cleaning up around it than any other device, in addition to its non-adaptability to a heated material such as comes from the tube mills. This latter disadvantage has been somewhat overcome by the addition of screw conveyors that allow the product to cool before coming in contact with the belt. The belt conveyor has an advantage in that it carries the material instead of shoving it as the screw conveyor does and does not consume as much power; in fact it is probably the most economical in this respect of any of the devices in use. It gives the most satisfactory service in the galleries of the stock houses.

A number of plants use considerable screw conveyors and some managers are pleased with the results with them in handling the finished raw material, but there are not so many who recommend them for the finished cement. Their advantages are their closed casings and consequently dustless operation and their compactness.

The objections to their use are their high repair expense, their slow revolution in comparison with the other machinery in the mill, and their low efficiency in the use of power. This low efficiency will go far to account for their rapid wear.

Considerable ingenuity has been shown in the design of hangers and gudgeons, but the problem of their correct construction seems almost impossible to solve. Their location in the material carried make them difficult to oil properly, the bolts in the connection to the conveyor soon wear large openings in the pipe and collar, and the bearing must be short and of simple design to avoid blocking the flow of material.

Some plants use screw conveyors in their cement without grease in the hanger bearings, and as the ordinary gudgeon will last only about three weeks under these conditions, they use an all cast-iron bearing, having a split collar on the gudgeon to take the wear. These collars are not so expensive to replace as the gudgeons, but wear out faster and also consume more power.

The slow speed of the screw makes it necessary to drive a long run of them with a geared or chain driven head. They become impracticable when the material is to be conveyed a great distance and are most satisfactory when used in single lengths delivering to some other form of conveyor.

The conveyor problem is often more complex in an old mill that is being rebuilt to increase its capacity. When an open quarry is being worked the raw material is often so damp that a belt conveyor from the crushers will give considerable trouble and it is not practical to use trippers either fixed or movable that involve the use of a pulley working in contact with the carrying face of the belt, as the belt will carry over enough of this sticky material that will adhere to the pulley face and cause the belt to give trouble. Scrapers only increase the difficulties.

Spouts handling this material should be steeper than 45°, and when so built, and delivering from one belt to another as where a number of bins are to be served, will, owing to their free discharge during dry weather, be very destructive to the belt. It is quite well understood that this material will give trouble at times with elevators, conveyors, bins and feeders, and an effort is usually made to get it into the driers as soon as practicable.

The machinery in use in a Portland cement plant is of a class that takes a continuous feed and delivers a continuous stream of finished product, and the conveying devices here mentioned are all intended to be entirely automatic in their operation and therefore will not require a large force of mill tenders; but their number, slow speed and necessary location usually make the arrangement of the drives very complicated.

Some of the transportation problems of a blast furnace or steel plant have requirements that are in a number of ways identical with those presented in the cement plant. The daily charge of a blast furnace is about the same as the daily charge of a row of kilns, and the skip hoist and larry car that have been developed for this work could easily be arranged to do any of the work at a cement plant. The problem of confining the dust is not insurmountable and would consist of a proper arrangement of car bodies and gates; nor would the heat of the clinker have the bad effect on the large journals used.

This use of a skip hoist and larry car should not be imagined as a further development of the hand operated truck, but a bold departure, with large cars, an arrangement of the different departments in detached buildings and the elevation of the machinery enough to make it possible to load a car, of ten or twelve tons capacity at the bins, under each machine or pair of machines or at the kilns.

The modern skip hoist used on a blast furnace is an electrically operated machine, automatic in its operation, and the larry car is usually a self-registering scale car. The use of these cars in the cement business will quickly solve some of the problems in regard to the proper form and use of grinding machinery; and the hoists, while having some disadvantages, are well understood by the men who use them and are not comparable in disadvantages with the trappy contrivances in use in the cement business. They are expensive machines, but one of them built on a scale in use in the blast furnace work, would easily serve a grinding department. The repair shop would at once be placed in convenient access to any of the machinery owing to the tracks running under each department, and an accident to any of this conveying machinery would not be such a catastrophe as to call out all the reserves, and there would be little occasion for a crowd of excited men to tinker a hot conveyor while the kilns cool off.

It is time for this industry to take its place among the industries and use methods of a dignity in keeping with its standing, and in this problem of transportation in which so much disagreement is in evidence, where could we look with better assurance of able guidance than to the modern steel plant.

THE RAILWAYS OF SIAM have a total length of about 485 miles, including 125 miles of line just built. Of this total, 390 miles have standard gage, while 95 miles have meter gage (3 ft. 3⅜ ins.). The cost of these lines has amounted to about $28,000 silver per mile for the standard gage, and $23,500 for the narrow gage. The operation is quite profitable. Passenger receipts constitute about two-thirds of the total receipts, and 98% of the passenger traffic is third class.

THE NEW YORK STATE BARGE CANAL work is described in the annual report of State Engineer Skene for 1907. During the past year contracts for $7,000,000 were let, bringing the total of work under contract up to $22,395,591. Plans are ready for further work aggregating about five million dollars, and it is expected that by the end of 1908 plans for all remaining work of importance will be completed. Work is now in progress at Waterford, Vischers Ferry, Rotterdam, Cranes Village, Amsterdam, Sylvan Beach (Oneida Lake), Seneca River, between Mosquito Point and Fox Ridge, Rochester, and between Lockport and Tonawanda. On the Champlain Canal work is going on at Fort Edward, Dunhams Basin, Fort Ann, Comstocks and Whitehall. On the Oswego Canal work is going on at Fulton and Oswego. Much study has been devoted to the problem of standardizing plans for locks, especially as relates to gates and gate mechanism, and this has resulted in 34 supplementary agreements affecting 16 contracts. A new bureau of electrical equipment is now investigating the subject of power development at the various dams in the system to furnish power for operating lock gates, movable dams, etc., and for lights. Some minor changes of location have been made in the canal. Between Fox Ridge and Macedon a new line 43 miles long, representing an increase of 8 miles, has been fixed, which renders the water supply simpler, gives better conditions in the Seneca, Clyde and associated streams, and reduces the interference with villages and towns. The location of the line in the vicinity of Rome is still under advisement.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering

Published every Thursday by

THE ENGINEERING NEWS PUBLISHING CO.

220 BROADWAY, NEW YORK

BRANCH OFFICES

CHICAGO: 1636 Monadnock Block
WASHINGTON, D. C.: Home Life Building
ATLANTA: Candler Building
RUDOLF MOSSE, BERLIN AND HAMBURG, GERMANY
Y. P. MARUYA & CO., Ltd., TOKYO, JAPAN

GEORGE H. FROST, President
CHARLES WHITING BAKER, Vice-President
HARWOOD FROST, Secretary
FRANCIS W. FROST, Treasurer

ALFRED E. KORNFELD, Manager
EDWIN HUNT FROST, Ass't Manager

CHARLES WHITING BAKER, M. N. BAKER, E. E. R. TRATMAN, F. E. SCHMITT, } Editors

SUBSCRIPTIONS

United States and Possessions, Mexico and Cuba, One Year, $5.00.
Canada, $7.00 a Year.
Foreign Countries, Regular (Thick Paper) Edition, One Year, $9.00. (£1-18-0.), 45 Francs or 37 Marks.
Foreign Countries, Thin Paper Edition (Construction News Supplement Omitted), $7.00. 29 Shillings, 35 Francs or 29 Marks. Remit directly to our office.
Pay no money to canvassers for subscriptions.
Remit by Post-Office or Express Money Order, Draft on New York or London, or by Registered Letter.
Notice of change of address should reach us one week in advance of removal. The old as well as the new address should be sent.
Subscriptions cannot be dated to commence with past issues. All subscriptions commence with current issue and back numbers can be supplied only by special order.
Receipts for Subscriptions will not be sent unless requested, the changing of the expiration number being considered sufficient. The number on the address label indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year. 52-7 means the 52d week or December 26, 1907.

ADVERTISING

"Contract": Rates furnished on application.
"For Sale": $1.50 per inch.
"Proposal": $2.40 per inch.
"Want": See "Want" Pages.

Copy for regular, or "Contract," Advertisements should be received at least ten days before publication; "For Sale" and "Situations Wanted" Advertisements by Monday, and "Proposal" and "Situations Open" Advertisements by 9 A. M. Wednesday.

Entered at the New York Post-Office as Second-Class Matter.

The short-sighted opposition of labor unions to the use of concrete has been familiar to engineers and contractors for years. This opposition, however, is fast disappearing at the present time as the value of skilled labor in placing concrete becomes more widely appreciated. In New York City the carpenters organization have recently come out in opposition to further restrictions upon the use of concrete, in the building code or elsewhere. Form work in connection with concrete gives employment to thousands of carpenters. From this time forward there should be little difficulty from the labor unions in extending the use of concrete.

The opinion is sometimes expressed that broken rails are not a cause of serious danger to trains. Any who may hold such an opinion will be interested to read the official report on railway accidents for the quarter ending Sept. 30 last. We there learn of a failure of a 100-lb. rail, in service nine years, which cracked between the head of the rail and the web. Four passengers and a trainman were killed and 13 were injured. Another case is recorded where a broken rail derailed a train running 50 miles an hour on a straight line, injuring 32 persons and doing $63,000 damage to the rolling stock. The breakage was due to an interior defect in the rail.

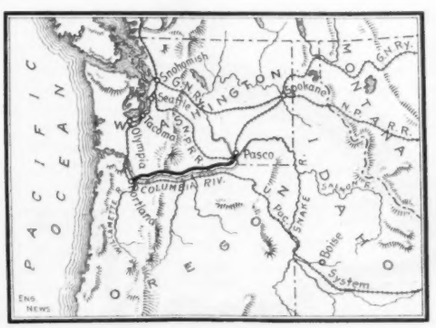
We can quote, however, statistics, which are even more convincing than isolated cases. On Oct. 1 last Mr. J. Kruttschnitt, of the Committee on Standard Rail and Wheel Sections of the American Railway Association, in a report to the Association, said:

> Roads covering a mileage of 159,351 miles report 24,023 broken rails in 1905 and 28,478 in 1906—an increase of 18%; but in 1905 there were 4,576 breaks attributed to piping, while in 1906 there were 6,379, an increase of 40% in breakages of piped rails. These breaks caused the death or injury of 65 persons in 1905 and of 339 in 1906, an increase of 420%.

This is proof positive that broken rails do constitute a danger to the traveling public, and that piped rails causing interior flaws are particularly dangerous. It is a clear refutation of the strong assertions made a year ago by railway managers that rail fractures were no more frequent than they had been and that the quality of rails was quite satisfactory.

Probably the most important piece of railway construction carried out in the United States in 1907 was on the Portland & Seattle Ry. in the State of Washington. Our leading article in this issue describes the construction of this railway; but we think it worth while to call especial attention to its strategic and economic importance. As elsewhere described, this new road gives an outlet from the vast grain fields and farms of eastern Washington to a Pacific Coast port without the toilsome and costly climb over the Cascade Mountain range.

It will be recalled that the Cascade range extends parallel with the Pacific coast from north to south across the whole width of the United States and reaches particularly high altitudes in the states of Oregon and Washington. At one place only is this high mountain wall broken through by a river flowing across it, and this is on the boundary between Oregon and Washington, where the huge Columbia finds passage. Many years ago a railway was built along the south bank of the Columbia by the Oregon Ry. & Navigation Co., which now forms part of the Union Pacific system; but the north bank, with its rugged shores and precipitous cliffs has never been occupied by a railway line until the present time. To make a railway line there has involved an enormous expense; but the task has been accomplished; and the work has been done with a clear vision of the future and of the vast volume of traffic which is destined to pour from the "Inland Empire" of eastern Washington to the markets on the seaboard.



Map of Railways in the Northwest, Showing Route of Portland & Seattle Ry. in the Columbia River Valley.

In the entire distance of 220 miles along the valley of the Columbia there is absolutely no rising grade against westbound traffic and for eastbound traffic the maximum grade is only 0.2%, or 10½ ft. per mile. The total rise in the distance is only 324 ft. Notwithstanding that the line is compelled to follow the narrow valley of the river, maximum curvature has been limited to 3%. That such a road will permit enormous train loads, and very low cost of hauling and will have great traffic capacity, can be seen at a glance.

The new road will give the Northern Pacific and Great Northern systems an outlet to tidewater that runs down hill all the way from the eastern side of the Cascade Mountains. Their present lines are shown on the accompanying map. The Northern Pacific crosses the Cascade range at an elevation of 2,827 ft., and the Great Northern at an elevation of 3,380 ft. Each road has grades as steep as 2.2% in their ascent of the mountains.

The new road is of interest also with relation to waterway competition. The lower Columbia is navigable for deep draft vessels all the way from the sea to the Columbia gorge; and above the gorge the river and its main tributaries are also navigable for a long distance. Rapids and falls, however, prevent navigation through the gorge. The lowest of these falls at the Cascades is avoided by a canal, built by the Federal Government many years ago; but the obstructions further upstream have remained to prevent continuous navigation and neutralize to a large extent the usefulness of the Cascades canal. Now, however, the United States is at work on a canal which will make it possible for river steamers to take on cargo at the towns on the upper river and discharge it at the wharves of Portland. It is noteworthy that this has not deterred Mr. Jas. J. Hill from spending many million dollars on a railway which will compete with water transportation lines for its whole length.

THE FUTURE OF THE CHICAGO DRAINAGE CANAL.

Few municipal enterprises in any part of the world equal the Chicago Drainage Canal in magnitude and in possible usefulness. The canal has already cost about $50,000,000,* and its completion, with important accessory works, will add many millions to that large sum. Designed primarily for the protection of the water supply of Chicago, its promoters have always intended that it should also form an important link in a deep-waterway channel from the Great Lakes to the Gulf of Mexico. Incidentally, a large amount of water power is now being developed at the south end of the canal where it discharges through a tail race into the Des Plaines River. Among the 28 miles of the canal the Chicago Sanitary District has acquired title to strips of land from 200 to 800 ft. in width, which will prove valuable assets in connection with the manufacturing plants that may be expected to locate there for the utilization of the water power just mentioned and to take advantage of the shipping facilities afforded by the canal. The canal, in conjunction with tributary railways, as can be readily seen, will afford a remarkable opportunity for the transfer of freight conveyed by boat through the future Lakes-to-the-Gulf Waterway, the shipping of the Great Lakes and the railway lines which radiate from Chicago in all directions.

The future of the canal as a means of protecting the water supply of Chicago, disposing of the sewage of that city, and as both a waterway and a harbor, will depend very largely upon the amount of water which the Government of the United States finally permits the Drainage District to divert through the canal. This diversion is closely related, on the one hand, to the depth of water which is to be attempted in the Lakes-to-Gulf Waterway, and, on the other, to the levels of the Great Lakes and the possible draft of vessels in their harbors and connecting channels. The greater the depth of channel attempted between the end of the Drainage Canal and the Gulf, the greater will be the need for diversion of water from the Great Lakes; and the greater this diversion, the more serious becomes the question of the lowering of the water in the Great Lakes and the reduction of harbor and channel depths and the draft of vessels. Another and very important factor entering into a consideration of the amount of water to be diverted from Lake Michigan is the effect of the volume upon the current in the Chicago River; and this, in turn, is intimately related to the continued use of the river as a harbor and the arguments for and against the development of a harbor or harbors at other points, as discussed at some length in our issue of Jan. 16. In addition to all this, there is involved, as was brought out in some detail in the issue just named, the effect of the decision as regards harbor location upon the plans being made by Mr. D. H. Burnham in behalf of the Commercial Club of Chicago, for the improvement of the general city plan of Chicago and the development of the water front for recreation, breathing spaces and esthetic effect.

Obviously, many of the questions involved in the points mentioned above are of far more than local interest, while those that do chiefly concern Chicago are of unusual importance and therefore worthy of consideration by the engineering profession at large.

In order that the Chicago Drainage Canal

*For expenditures in detail to the close of 1906, see Eng. News, April 11, 1907.

problem and allied matters may be understood, a few facts may be here given regarding the principles involved in the design of the canal, the capacity thus far provided and in contemplation, and a number of other related matters.

The Chicago Drainage Canal is the result of fifty years' agitation for a means of sewage disposal for Chicago that would both protect the water supply of the city, as drawn from Lake Michigan, and do away with the nuisance caused by converting the naturally sluggish waters of the Chicago River and branches into a huge serpentine cesspool. Throughout the half-century there has always been more or less distinctly in mind the possibility of providing a deep waterway from Chicago to and through the Mississippi to the Gulf.

When the Drainage Canal problem was attacked by Mr. Rudolph Hering, M. Am. Soc. C. E., and others, in 1889, the first question to be answered was the amount of dilution necessary to render the sewage of Chicago inoffensive to sight and smell in case the natural flow of the Chicago River was reversed and it was turned, and with it the sewage of Chicago carried, to the headwaters of the Des Plaines and then on to the Illinois and Mississippi rivers. As a tentative minimum it was decided that it would be necessary to divert from Lake Michigan, for the dilution of the sewage of Chicago, 3⅓ cu. ft. of water per sec. per 1,000 population.

In the legislation authorizing the construction of the Drainage Canal,* it was provided that the canal should be given a cross-section sufficient for a flow of 10,000 cu. ft. per sec. through rock, and 5,000 cu. ft. per sec. through earth, or flows of 600,000 and 300,000 cu. ft. per min., respectively. On the minimum-dilution basis named above, a flow of 300,000 cu. ft. per min. provides for the sewage of 1,500,000 people, which is the population that is now believed to be tributary to the Drainage Canal. The rock section, as designed, would provide for 3,000,000 population, but the use of channeling machines in excavating the canal through the rock gave a smoother surface than was figured on before it was known that such machines would be used, so that the rock section, which composes the greater part of the length of the canal, is actually capable of accommodating a flow of 840,000 cu. ft. per min. (14,000 cu. ft. per sec.), or sufficient to take care of the sewage of population of 4,200,000.

The trustees of the Sanitary District of Chicago, finding themselves with a canal capacity for the greater part of its length sufficient for a population of 4,200,000, and meanwhile the population of Chicago and vicinity having rapidly increased and the area of the Sanitary District having been materially enlarged, have very naturally made plans for developing the canal and its feeders, including the Chicago River, so as to carry through the whole length of the canal a volume that can be handled by the rock section. The reason for thus increasing the canal capacity is strengthened by the water-power development already entered upon at Lockport and the further developments that could be made at Joliet.

At this point it may be noted that the area of the Sanitary District was increased in 1903 from 185 to 358.1 sq. mi. by taking in 78.6 sq. mi. along the north shore of Lake Michigan, extending beyond Evanston, and 94.5 sq. mi. to the south to include the Calumet District. The area of the City of Chicago being 190.6 sq. mi., the Sanitary District now comprises 167.5 sq. mi. outside the city limits. The north shore addition has been or soon will be provided for by various feeders to the Drainage Canal. These, together with the territory tributary to the river and canal, and an additional territory recently made tributary to the southward, will divert from the lake all the sewage of the present Sanitary District except the 94.5 sq. mi. in the Calumet area; and this, without increasing the flow through the Drainage Canal beyond 10,000 cu. ft. per sec., or 600,000 cu. ft. per min. Moreover, some of the feeders are brought into the canal in such a way that they do not increase the current in the main portion of the Chicago River (see accompanying map, which originally appeared with Mr. Rudolph Hering's report on sewage disposal in the Calumet District, summarized in Eng. News, Nov. 7, 1907). The Calumet District now has a population of perhaps 200,000, and in making estimates for the future provision has been made for the sewage from a population of 1,200,000. This would add 4,000 cu. ft. per sec. to the volume of flow through the Drainage Canal, by means of a branch canal to join the main canal at Sag, in the rock section. This additional quantity would fully utilize the capacity of the rock section of the canal and, as already stated, would take care of the sewage of a total future population of 4,200,000, or about double the present population of Chicago alone.

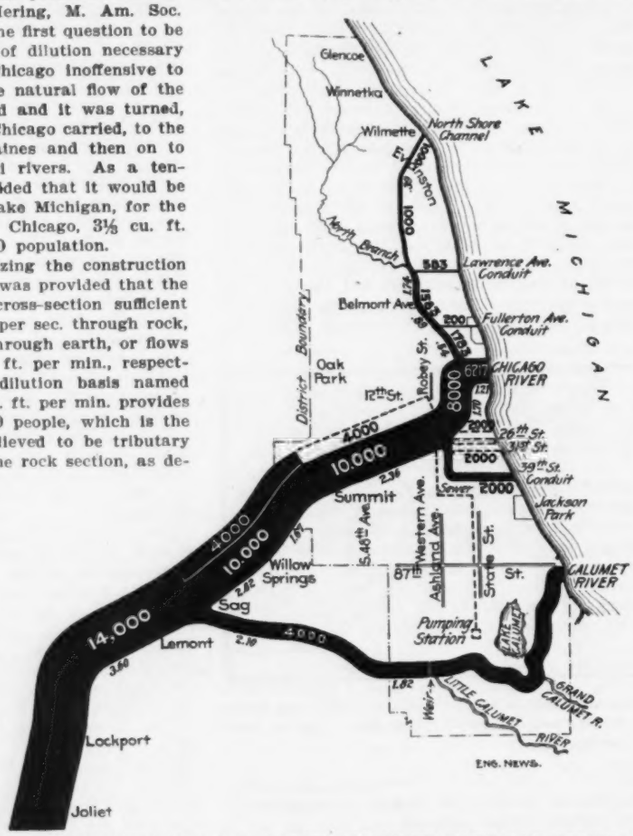


DIAGRAM SHOWING PROPOSED CALUMET RIVER AND OTHER CONNECTIONS WITH CHICAGO DRAINAGE CANAL.

(Reproduced from Eng. News of Nov. 7, 1907. The black area indicates relative discharge capacity of finished and proposed works. The heavy broken lines indicate alternative proposals. The large whole numbers indicate discharge capacity in cubic feet per second; the italic numbers, expressed in units and decimals, indicate mean velocities in feet per second.)

Against the 14,000 cu. ft. per sec. of Drainage Canal capacity contemplated by the trustees of the Sanitary District, the War Department now permits a flow of only 4,167 cu. ft. per sec., or 250,000 cu. ft. per min., which is not quite enough to provide, for the present population, the dilution demanded by the Illinois Legislature. This restriction is due to complaints of interference with navigation by excessive current in the Chicago River during a period when a higher flow was permitted. It is expected that as soon as contemplated* improvements in the Chicago River are made, the Government will permit a material increase in the flow through the Drainage Canal, but it is to be noted that the International Waterways Commission, in its report of Jan. 4, 1907, recommended that Congress prohibit the discharge of more than 10,000 cu. ft. per sec. through the Drainage Canal (see Eng. News, Jan. 31, 1907).

The Commission held that "with proper treatment of sewage from areas now sparsely occupied" this would provide for the sanitary dilution of the sewage of Chicago for all time, and incidentally that it would also provide for the deepest navigable waterway from Lake Michigan to the Gulf that has ever been considered by Congress (14 ft.). This opinion, it should be noted, was based on the assumption that the sewage of the Calumet District might more properly be treated by septic tanks and sprinkling filters than disposed of by dilution, in accordance with a plan and estimate made by Hering & Fuller (see Eng. News, Jan. 31, 1907).

In submitting this plan and estimate, it should be borne in mind that the engineers named were asked to consider the feasibility, from the hygienic viewpoint, of disposing of the sewage of the Calumet District otherwise than by the Drainage Canal. In a subsequent report (Eng. News, Nov. 7, 1907), Mr. Hering, of the above-named firm, gave estimates showing that, water-power possibilities considered, sewage disposal by way of the Drainage Canal would be cheaper than by means of a sewage purification plant.

Attention may now be turned to the relation of the future of the Drainage Canal to the water supply of Chicago. With the completion of the intercepting sewers and other works now under way, practically all the sewage of Chicago will be diverted from Lake Michigan, except that from the Calumet District. The effect of the diversion thus far made, as shown by water analyses and particularly by typhoid death rates, has been of great benefit. It is important, however, that the sewage from the Calumet District now going into the lake be also taken out, and much more important that the sewage of this rapidly growing district be kept out of the lake in the future.

If the Drainage Canal capacity be restricted to 10,000 cu. ft. per sec., the population of 3,000,000 thus provided for will be only 50% in excess of the present population. Chicago has doubled in size since 1890, its population having increased in that time from about 1,100,000 to 2,100,000. The same arithmetical rate of increase would give over 3,000,000 population in 20 years. The future growth of Chicago, however, will doubtless be distributed over a greater part of its large area than has been the case in the past, and in addition the almost equal area within the Drainage District and outside the city limits, including important residential suburbs like Evanston, must also be reckoned with. Account must also be taken, in considering future chances for the pollution of Lake Michigan, of the large population to be expected on the lake shore to the east of the Drainage District in the State of Indiana, through such developments as the building of the great plant and industrial town of the U. S. Steel Corporation at Gary.

From the foregoing summary, it can be seen that the future of the Drainage Canal is of the utmost importance to the water supply of Chicago. The only way to prevent contamination of the water supply is to utilize the Drainage Canal to the utmost, or else purify the sewage of part of the city and district. For the central portion of the city, using "central" in a broad sense to include all but the outlying districts, there seems to be no question but what purification of the sewage would be utterly impracticable. It would be possible, according to the report by Hering & Fuller, to purify the sewage of the Calumet District, but to do so would be more expensive than disposal by dilution through the agency of the Drainage Canal. If the Calumet District sewage were excluded, the

*See Eng. News, Dec. 7, 1899, and Aug. 9, 1900, for preliminary and final report of a State Commission appointed to determine whether or not the canal, as built, complied with the legislative requirements. Mr. Desmond FitzGerald, M. Am. Soc. C. E., was engineer to the commission.

*Some, at least, of these complaints were due to the fact that river navigators had not yet become accustomed to the change of the river from a general condition of slack water to one of a moderate current.

Drainage Canal, even if limited to a flow of 10,000 cu. ft. per sec., would serve for many years to come.

Pending the time when the population would demand this volume, the question arises whether it might not be feasible and far cheaper to send the Calumet sewage to and through the main canal, even if it were to be purified at a later date, in view of the fact that there are still many unsettled problems in connection with sewage treatment, it might prove highly advantageous to defer as long as possible the construction of sewage purification works for any considerable population. The general argument for such postponement is strengthened, in the case of the Calumet District, by the advantages that would flow from the Calumet-Sag Canal through its use for navigation purposes, as mentioned further on, as well as by the possible water power developments already discussed.

Before dismissing the sewage disposal and water supply phases of this discussion, mention may be made of the possibility of a reopening of the famous Chicago-St. Louis Drainage Canal controversy, in which the U. S. Supreme Court finally decided that there was not sufficient ground for enjoining the diversion of the sewage of Chicago to the possible detriment of the water supply of St. Louis. (See Eng. News, March 1, 1906, for decision in full.) As the amount of sewage thus diverted increases, of course the argnment for an injunction in favor of St. Louis would be strengthened. But the greater the dilution, the less the danger to St. Louis and cities on the Illinois River.

As to the water-power phases of the future of the Drainage Canal, little need be added to what has already been said. The water-power plant at Lockport, already partly completed, will include five units of 8,000 HP. each. The 4,000 cu. ft. per sec. flow through the proposed Calumet-Sag Canal would add some 22,500 HP. to that capable of development by means of the 66 ft. of fall at both Lockport and Joliet. At Lockport alone, with a head of 34 ft., the flow of 10,000 cu. ft. per sec. to which the International Waterways Commission would limit the capacity of the Drainage Canal, would give 28,000 HP. (electric), while the 14,000-ft. capacity desired by the Sanitary trustees would give 40,000 HP. The greater the volume of flow through the Drainage Canal, the greater the water power and sewage disposal possibilities, and the greater the economic benefit to the District and to Chicago through the reduction of the cost of sewage disposal, and all the many advantages that will flow from cheap power along the canal and in Chicago. At the same time, navigation and commerce would be helped by the increased diversion, both directly and indirectly. The gain will be offset only by the increased difficulty of navigating the river, and by such harm as may result to harbor facilities by the increased current in the Chicago River and by the lowering of the level of the Great Lakes.

The relation of the future of the Drainage Canal to harbor facilities at Chicago, including currents in the river, was discussed at such length in our issue of Jan. 16, 1908, that nothing more need be said at this point, except to point out that the construction of the Calumet branch canal, with its proposed depth of 25 ft., would provide what might be termed a by-pass to the main Drainage Canal for through traffic by way of the Great Lakes and the Lakes-to-Gulf Waterway, thus relieving the narrow Chicago River of that much traffic and at the same time obviating the delays to through navigation which are caused by the many bridges across the Chicago River. (Estimates of the cost of a radical improvement of the Chicago River, including widening it to 300 and to 360 ft. and deepening it to 25 and to 26 ft., were published in our issue of April 4, 1901.)

We now come to the Lakes-to-Gulf deep waterway project. The Drainage Canal already has a depth of 22 ft. throughout its entire length, and a depth of 26 ft., we understand, has been given more or less serious consideration, and was called for in a bill recently before the Illinois Legislature. The Chicago River has a navigable depth of only 17 ft. at present, but in accordance with requirements of the general Government the tunnels underneath the river, which have prevented a greater depth, are being lowered and before long a depth of 26 ft. will be provided. This depth, it will be seen, by greatly increasing the cross-section of the river channel, will make possible an increase in volume without causing prohibitive velocity. With depths of 26 ft. in the Chicago River, 25 ft. in the proposed Calumet-Sag Canal and 22 ft. (with a possible 26 ft.) in the Drainage Canal, Chicago and vicinity would be provided with magnificent local navigation and harborage facilities, which will accommodate larger lake steamers than can make use of the present harbors on the Great Lakes and the channels connecting the Lakes, the low-water limit to boat draft now being 19 ft. The river and canal facilities would afford unsurpassed opportunity for the interchange of freight between the railways and lake shipping and would provide in like manner for all possible interchange with the railways and boats passing to and from the Mississippi.

What is the maximum depth of channel that is likely to be demanded by the last-named boats for any reasonable number of years to come? As we pointed out in an editorial discussion in our issue of Oct. 10, 1907, even the enthusiastic promoters in attendance at the Deep Waterways Convention at Memphis, last fall, did not presume to advocate, in their final resolutions, a greater depth than 14 ft. for the channel from the lower end of the Drainage Canal to the Gulf. We assumed, in the editorial mentioned, that probably a depth of 14 ft. would be as good as any greater depth, and that possibly a smaller depth would serve all commercial purposes equally well.

Enthusiasts may talk of bringing ocean vessels up the Mississippi and Illinois rivers to Chicago; but when any such proposal is seriously studied it is apparent even to a layman that economy in transportation would not be effected even if the scheme were practicable.

The investigations of a Board of U. S. Engineers in 1905 indicated that a flow of 10,000 cu. ft. per sec. from the Drainage Canal added to the natural flow of the Illinois River would be sufficient for a 14-ft. navigation in the lower reaches of that stream, where it flows through an alluvial valley for a distance of some 200 miles. Above that point, the fall of the river is much greater and slack-water navigation by locks and dams is essential. Here, of course, the amount of water required is only the small amount necessary for lockage.

The great difficulty in securing a really deep waterway to the Gulf is encountered south of St. Louis, and particularly in the 186 miles between St. Louis and Cairo. For some ten years past, the Mississippi River Commission has maintained a minimum depth of 8½ ft. in the channel of the lower Mississippi during the low water season by hydraulic dredging on the bars between the pools. How much this depth can be increased it is impossible to determine. The situation is wholly unlike ordinary dredging work, where the depth to be secured is simply a matter of the amount of digging done by the dredge. On the Mississippi the dredges' work is solely to deepen the channel across the shallows which connect the successive pools that lie in the river bed at the lowest stages of the river. The actual channel from pool to pool is formed by the current of the stream itself, when the dredge has made the opening cut, much more than by the excavation actually done by the dredge. It would not be possible, therefore, to secure a channel of much greater depth simply by increasing the amount of dredging. The present dredges cause the river to concentrate its flow in a deep channel between the pools and dredges twice as powerful or twice as numerous could do little more.

Unfortunately, the bed of the Mississippi is too broad, even at low water stage, for the contributions from Lake Michigan through the Drainage Canal to have any considerable effect on the navigation of the river. Yet all that is gained is, of course, beneficial, and for the navigation in the lower portion of the Illinois River, as above pointed out, a large flow in the Drainage Canal is essential.

Ever since the Drainage Canal was first projected, its effect upon the levels of the Great Lakes has been a controverted question. No one doubts, of course, that any permanent and material lowering of the lake levels would injure all the harbor and navigation interests on the lakes, and Chicago herself would be one of the chief sufferers. The injury due to serious permanent lowering of the lake levels would not be confined to the lakes, but would extend to the St. Lawrence River in Canada and to the utility and scenic effect of Niagara Falls.

According to the recent report of the International Waterways Commission (see Eng. News, Jan. 31, 1907), a diversion of 10,000 cu. ft. per sec. from Lake Michigan (which the Commission concedes is necessary) would by the end of five years lower the level of the Great Lakes, and the Detroit, St. Clair and St. Lawrence rivers, by amounts varying from 4¼ to 6¼ ins., while a diversion of 14,000 cu. ft. per sec. would cause a lowering of 6 to 8½ ins. These figures apply to average lake levels, and would be increased at periods of low water. If the diversion were increased still further to 20,000 cu. ft. per sec., or 1,200,000 cu. ft. per min., thus affording sufficient dilution for the sewage of a population of 6,000,000, it is estimated that the levels of Lakes Michigan and Huron would be permanently lowered 1.1 ft. and the level of Lake Erie 0.9-ft. To make good the lowering caused by the Drainage Canal diversion, either dredging of harbors on the Great Lakes or maintaining their levels by means of dams, would be required. The Commission gives estimates of the cost of making good the lowering by means of dredging. This cost is placed at $10,000,000 for the lake harbors and connecting channels, and $2,500,000 additional for the Welland and St. Lawrence canals. Apparently, the estimate is based on dredging to a depth of 1 ft., but if such a depth were dredged, then the effect of a diversion up to nearly 20,000 cu. ft. per sec. would be overcome.

It is probable that equally good or better results might be attained by the erection of controlling works at the outlet of Lakes Erie, Huron and Ontario, and at considerably less cost. Such works have been repeatedly proposed and their value in regulating the stages of the lakes, apart from any question of the abstraction of water by the Drainage Canal, seems certain to cause them eventually to be undertaken.

In reviewing a subject of such magnitude and with as many ramifications as the one under discussion, it is, of course impossible in the space at our command to do more than touch upon the various points involved. We trust, however, that we have made it clear that the interests of both the Sanitary District of Chicago and of the nation at large demand that all these matters shall be given due consideration in any action taken by city, state or nation respecting the Drainage Canal.

The Commission* already appointed by Mayor Busse, of Chicago, may be expected to take a broad view of the local questions at issue, which really include some of the national questions as well. It is to be expected, in addition, that President Roosevelt's Inland Waterways Commission will go exhaustively into all the national phases of the subject and that it will cause some authoritative statement to be made as to the depth of channel feasible for the Lakes-to-Gulf Waterway, the amount of water from the Great Lakes needed therefor, and the effect of such diversion upon the harbors and connecting channels of the lakes.

Finally, we venture to express the belief that, without prejudice to lake navigation interests,

*The commission consists of seven members, as follows: John M. Ewen, Advisory Engineer for the new city hall; Chas. A. Wacker, Capitalist; F. A. Delano, President Wabash R. R. Co.; Isham Randolph, Consulting Engineer of the Drainage Canal; C. H. Conover, Vice-President of Hibbard, Spencer, Bartlett & Co.; Peter L. Hoffman, Chairman Council Committee on Harbors, Wharves and Bridges; and Chas. M. Foell, of the Committee just named. The commission has chosen Mr. Ewen as chairman and has appointed as secretary, Prof. Chas. E. Merriam, of the University of Chicago. The committee is to consider the respective merits of harbor facilities along the lake front, at the mouth of the river, or in the river (as at present) with due regard to the utilization of the lake front for public purposes.

it may be found possible to permit the diversion of at least 14,000 cu. ft. per sec. through the Chicago Drainage Canal, thus bringing to a successful consummation one of the most ambitious and worthy engineering enterprises ever attempted by a great municipality. Such a diversion would protect the water supply of a future population of 4,000,000 to 5,000,000, solve a sewage disposal problem perhaps more difficult than any ever before presented, provide unsurpassed harbor and railway terminal facilities at the nation's greatest inland commercial center, and lay a broad foundation for a waterway system whose benefits will be felt throughout the continent.

LETTERS TO THE EDITOR.

The Comparative Costs of Operating Private and Municipal Pumping Plants.

Sir: Referring to John W. Hill's communication published in your issue of Jan. 9, 1908, in reference to comparative costs of operating private and municipal pumping plants, I would say that my original letter was not intended in any way as a criticism of Mr. Hill's contention as to the relative economy practiced in municipal and private plants, but was merely for the purpose of calling attention to what I considered an error in the method of comparing costs of operation on a "horse-power" basis.

The point of my argument was not, as Mr. Hill apparently thinks, that large units of machinery are relatively cheaper than smaller ones, but was that engines of a given size, weight and degree of complication develop five times as much horse-power when installed as power engines as when used as pumping engines; this difference in power being principally due to difference in piston speed, and somewhat due to the higher mean effective pressures carried on power engines. As the labor required to attend an engine is nearer proportional to its size and complexity than to the horse-power developed, it follows that the cost of attendance is not at all proportional to the horse-power developed by the two classes of machines.

As regards the item of repairs, I thoroughly agree with Mr. Hill that other things being equal it is lowest for engines running the lowest number of revolutions per minute, and the deterioration of pumping engines is usually very much less than that of power engines of the same bulk.

Of course outside of the engines, the deterioration of auxiliaries, such as boilers, etc., is practically the same as that of an ordinary power plant.

Irving H. Reynolds.

Youngstown, O., Feb. 5, 1908.

Advertising Defacements in the New Washington St. Rapid Transit Subway, Boston, Mass.

Sir: During a recent visit to Boston the writer had the good fortune to go into the new Washington St. tunnel, and, as every engineer must be, was greatly impressed with that colossal work which the city, through the engineers of the Boston Transit Commission, is carrying to completion. He was also surprised to see in one of the underground stations which was receiving its ornamental finish, that spaces, about 2 × 3 ft., or perhaps a little larger, and about 30 ft. apart, were being left upon the walls where the white finish was being omitted. The writer was informed by his guide that these spaces were for advertising matter, the Boston Elevated Ry. Co., which leases the Boston subways, having insisted upon these spaces.

The recent action of Justice Leventritt, in a similar situation in New York, as set forth in a press dispatch dated Jan. 18, is in pleasing contrast:

> Municipal efforts to develop a city beautiful and prevent commercialism from offending the artistic sense were given an uplift today when Justice Leventritt, in the Supreme Court, decided that the suit brought against the city by the Fifth Ave. Coach Co. to enjoin municipal interference with the advertising signs displayed on the exterior of its busses must be dismissed on its merits.
>
> The busses plying up and down fashionable Fifth Ave. succeeded a year ago the old stage coaches which were regarded as relics of old New York. The new double deck electric busses were plastered from top to bottom with garish advertising signs. The Board of Aldermen passed an ordinance giving the city the power to remove the advertising signs.
>
> Justice Leventritt today held the ordinance to be constitutional and after describing the beauty of Fifth Ave., with its churches, residences, clubs and hotels, declared: "It is amid such scenes as this that the plaintiff's advertising panorama of brilliant signs moves. It is along this avenue of churches that on Sundays these glaring billboards are driven. It is the scheme of beauty which is sacrificed to the demands of modern commercialism."

Not that the Boston subway passenger, in going through the stations to and from trains, passes through a locality comparable to Fifth Ave., yet it seems a pity that these stations, which are being built at public expense, and which are being fitted up in truly good taste, with their white walls of mosaic, enameled brick, decorative station signs, wrought iron fences, and the neat gold and black signs of direction and information, should be marred with glaring advertising. And is the Boston Elevated Ry. Co. contributing to rapid transit when it displays advertising signs in its stations and passageways? The subway traveler is usually in a hurry, but if some care-free individual does stop to read, the hungry bread earner behind him may not sympathize with the former's literary taste in the homeward supper-time rush.

In these days of growing interest in civic improvement and adornment of buildings, public places, and structures of all kinds, it seems as though Boston was forgetting something. In regard to the ugly, glaring billboard, Boston seems to be one of the worst offenders. Even in commercial New York there are some who do not wish to see the artistic sense offended.

Wilson T. Howe.

Huron, Ohio, January 25, 1908.

[It is certainly surprising that such things should be allowed in Boston, of all cities, and especially after all the public agitation against a similar but less well regulated practice in New York. Such advertising, unfortunately, is not confined to rapid transit subways nor to elevated railroads. The Erie Railroad Co. has recently offended its suburban patrons by renting advertising billboards on its stations and platforms to some enterprising railway advertising concern. President Underwood, in answering numerous letters of protest, has sought to mollify the protestants by announcing that only decorously costumed figures would be allowed on the billboards and that whiskey-advertisements would be prohibited. But this does not reconcile the average commuter to seeing twice each day, at his home station and at the Jersey City terminal, three to six large posters depicting an old lady, a middle-aged woman and a girl about to be relieved from backache, neuralgia and a bruise, respectively, by an application of ——— ———. It is high time for public opinion to put a stop to the billboard nuisance. Organized effort to that end has been successful in some places and might sweep away most of the billboards that now deface the face of nature and the works of man alike. Those desiring to aid to this end can secure information as to what has been done and is being attempted by addressing the American Civic Association, North American Building, Philadelphia, Pa.—Ed.]

The Waterproofing of Concrete.

Sir: The writer has been much interested in the paper read a short time ago by Mr. R. H. Gaines before the American Society of Civil Engineers, and equally so in the editorial comments which, together with the paper, appeared in Engineering News of September 26, 1907.

Engineering News has undoubtedly done a good work in calling the attention of the profession to the importance of providing water-tight concrete in reinforced-concrete construction, as the unknown element of danger resulting from the influence of electrolysis and rust is one that must be taken into serious consideration in calculating on reinforced-concrete work. There are, however, certain opinions expressed both in the paper and in the editorial above referred to, from which the writer must somewhat dissent.

In the first place, that concrete may be rendered water-tight and at the same time may be increased in strength by the addition of clay or alum, is neither so surprising nor so new as the editorial seems to import. On the contrary, these facts have been known to those who are conversant with the manufacture of waterproofing materials for some time; they have been called into practical use in various forms of construction work and form the basis of many successful waterproofing compounds now on the market.

There is no question but that a material which is so much finer than the cement itself, added in a small quantity to the latter would tend to close the voids and thereby assist in barring the passage of water, at the same time producing a denser and stronger mixture.

The editorial also states that there are cases without number where we resignedly allow water to percolate through our concrete structures because we cannot help ourselves. The writer believes both from observation and experience in the waterproofing of concrete, that most of the cases where water is causing trouble are found upon investigation to be due, not to the lack of efficient protective measures, but because the architect, engineer or other designer neglected to take advantage of the opportunities, which were to be had for the asking, for making the structure watertight. He certainly could have helped himself by making necessary provision against water and dampness before the structure was built. There are hundreds of buildings all over the country where surface coatings have been applied to concrete buildings and the penetration of moisture absolutely prevented during the life of the material, and a regular periodical renewal of the waterproofing material would preserve the water-tightness of the structure indefinitely.

There are also any number of buildings where the addition of a small percentage of waterproofing compound to the cement before mixing, has been effectual in excluding moisture, the interior of the building remaining water-tight under very trying conditions. Unquestionably, good waterproofing costs money, but the expense is almost always more than justified by the results.

With reference to the paper of Mr. Gaines, his theory he propounds as to the setting of cement, while appearing very reasonable is still by no means certain. This may be said of most other theories which have been advanced for the purpose.

There is one feature, quite distinctive of many commercial waterproofing compounds which is entirely overlooked in Mr. Gaines' paper, that is, their anti-hydrous or water repelling character. He states that some waterproofing compounds are built up on correct chemical lines while others are not so constituted; but in his investigations he seems to have entirely missed the point that many manufacturers claim for their material, that it is inherently water shedding and that the tendency to absorption of water by the treated concrete is in this way eliminated.

In the article on the "Disintegration and Decay of Masonry," which appeared in the August number of "Waterproofing," the writer went into the subject of capillary attraction and the significant part it plays in the theory of waterproofing and the manufacture of waterproofing materials. In the September number of the same journal there appeared a discussion on the value of cement waterproofing compounds, in which authorities of high standing laid much stress on the water-repelling properties of the compound. While clay is an excellent void-filler, and may produce impermeability through its action as such, the compounds of a stearic or waxy nature possess not only the void filling property of clay but are also "capillary negative" exerting a repulsion to water to a marked degree. Short time tests at least have shown that mortar made from such compounds tend towards an increase in strength, also an increase in bonding power with old concrete work and a loss of the tendency to absorption of water. The writer has been experimenting with concrete blocks for some time, has had them immersed in water for many weeks and while the untreated concrete would absorb water like a sponge, that treated with a small percentage of the compound would, invariably, be found perfectly dry in the interior when broken.

This repelling property is of paramount importance in superstructural work, as it is through capillary attraction that water largely works its way to the interior of concrete walls, and when a concrete, which, in the untreated state is essentially "capillary positive" or water drawing, is converted to a condition of "capillary negative" or water repelling, an important change has been effected which certainly Mr. Gaines should have considered. We are now testing briquettes similarly made, but substituting clay mixtures, and the results will be interesting in this connection. The absorption through capillary action is unquestionably much greater where clay is the filler than when an anti-hydrous filler is used. In fact we are of the opinion that no material added to cement which does not possess a natural repelling action to water will be efficient in waterproofing structures such as concrete block buildings as the capillary action is not destroyed.

There is something very peculiar in the setting of cement to which an anti-hydrous filler has been added. One would naturally think that a material which sheds water would tend to deprive the cement from water necessary to proper setting and that a material which is of different specific gravity would tend to separate from the mixture, but neither of these anticipated results are found to be the case by actual tests. It seems that neat cement so treated shows a decrease in strength, but a mortar shows a decided increase in strength and the bonding between new and old concrete work is increased in strength. These results have been verified by tests made by different manufacturers entirely independently of one another.

The writer also wishes to dissent from the statement of Mr. Gaines that authorities are agreed that bituminous materials have only limited durability and lose their efficiency for waterproofing purposes. There is no agreement of authorities upon the subject as far as the writer knows. Thousands of structures have been treated with bituminous materials and are as dry today as when constructed. When the bituminous compounds are thoroughly protected from atmospheric influence and from deleterious action of gases, there is no cause for fear as to the continued efficiency of the waterproofing.

When bituminous waterproofing has failed, investigation often brings to light the fact that the fault lay with the design or the construction and not with the

material or method. In fact one of the most frequent if not the principal cause of failure of waterproofing, is inadequacy in the design of the work, or the selection of material or method not best suited to the conditions. Structures may be waterproofed in numerous ways, but in different cases those materials and methods of procedure must be adopted, which best suits the conditions and unless this is done failure is to be anticipated. The waterproofing of a structure must receive the same degree of study and technical treatment as other engineering problems, if durable and economic results are to be had.

In numerous instances failure is the direct result of lack of familiarity with the subject on the part of the designer and often of inadequate inspection of the work.

If it were true, as Mr. Gaines states, that the waterproofing quality of bituminous materials is soon lost, all our deep tunnels in which these materials have been employed for waterproofing are in danger some day or other of being inundated, and precautionary measures should be taken before such contingency actually arises. But the writer does not agree that such is likely to be the result when the waterproofing has been efficiently done, and very few engineers will take the position of Mr. Gaines in the matter. Yours truly,

Myron H. Lewis, C. E.,
Consulting Waterproofing Engineer.

1133 Broadway, N. Y., Jan 14, 1908.

[We did not claim in the editorial referred to that waterproofing of concrete by the addition of electrolytes or colloids was an entirely novel process invented by the experimenters in the laboratories of the New York Board of Water Supply. We said, in fact, that such an addition was probably the basis of many patented compounds and processes on the market. But so far as we are able to discover Mr. Gaines' was the first sound and well-conceived explanation of the reasons for the increased impermeability and strength of a concrete to which had been added colloidal clay or electrolytes, and also the only occasion when this simple process was brought to the attention of the average engineer.—Ed.]

The Function of the Consulting Bridge Engineer.

Sir: In connection with the investigation of the Quebec bridge disaster a point has been raised, which, in my opinion, is likely to produce an erroneous impression on the minds of your readers. I, therefore, beg permission to call attention to the matter and to give you my views thereon for publication.

From p. 475 in your issue of Oct. 31, I quote the following:

Q. Do you consider that it is wise practice when building a bridge of novel character and unprecedented dimensions to place the design of the structure and of the methods of erection in the hands of the mechanically trained staff of a contracting company and, if not, why was this practice allowed in this case?

A. In answer to this question, it is the general practice in America to have the mechanically trained staff of contracting companies prepare the working plans. As a rule, no engineer could afford to maintain a staff of such character and no corporation would listen to a fee that would cover any such expense.

And from your editorial on p. 587 in the issue of Nov. 28, I quote this statement:

The normal and proper way of constructing any great engineering work which is done by contract is for two engineering organizations to work together. The one representing the contractor and the other representing the purchaser can check each other's errors, can study the work from different points of view and can produce a better and more economical result working in co-operation than either could working alone.

If these statements are not contradicted, the general public will be led to believe that American bridge specialists are incapable of designing great bridges, that they have to fall back upon the superior (?) knowledge of the bridge companies, and that their sole function is to check the numerical work (and perhaps also the honesty) of the manufacturers' designers.

Unfortunately, the old and still too prevalent custom of railroad companies of having strain-sheets prepared by their own engineers and of leaving the detailing to the bridge manufacturers lends some credence to this notion; but I beg to state most emphatically that any consulting bridge engineer who is truly worthy of that distinguished appellation is not only capable of preparing complete designs for bridges of all kinds, but also makes an exclusive practice of so doing.

The consulting engineer who prepares specifications, or specifications and strain-sheets only, and submits them to bridge manufacturers for the detailing is shirking his work and is not earning his pay. Once in a while some railroad company, as a matter of supposed economy, insists that its designing must be done in this manner; but the result is almost invariably unsatisfactory in that, if the engineer fail not in his full duty, he will do far more work than he is paid for, and in that the resulting structure is inferior to what the engineer would himself have designed, because the outcome as regards the detailing is invariably a compromise. On a few occasions I have been placed in this predicament, and the result has always been unsatisfactory. As a matter of fact, little or no economy results, for when the contractor does the detailing, the cost thereof must be borne by the purchaser just as truly as though the consulting engineer did the work and was paid directly for it; because this item is hidden in the total cost of the structure. Such economy as the practice entails springs from the fact that the contractor employs cheaper and less competent men to do the work than the consulting engineer does.

That the railroad companies of this country are beginning to understand this matter is shown by the fact that a number of the principal systems have established bridge departments of their own for the purpose of preparing complete detail plans for all the new bridges required as well as to supervise the maintenance of old structures. Again, many other railroad systems employ independent consulting engineers to do all their bridge designing and to supervise the construction of all important structures.

To the practice of letting the superstructure manufacturers prepare the plans of bridges is due the fact that so many railroad structures wear out and have to be renewed. Such structures fail invariably in the details. An old bridge designed by a manufacturing company ordinarily reaches the danger limit when, according to the best modern specifications for designing, it is overstrained 50%, or in some cases even less; while a really scientifically detailed bridge will be perfectly safe under much greater overloads. In confirmation of this statement I would mention the fact that, so far as I know, as yet no metal bridge of mine has had to be replaced, although many of the old ones are greatly overloaded, while similar structures designed by manufacturers at the same time, for the same roads, for identical live loads, and for like intensities of working stresses, have had to be taken out because of weakness in the connecting details, as evidenced by loose rivets and excessive vibration.

In defence of the few American bridge specialists who can properly claim to be entitled "Consulting Bridge Engineers," and who are entirely disassociated from the manufacturers, my firm being included, I desire to state that we have offices so organized that the entire designing in every detail of a structure as large and important as the Quebec bridge, or even larger, would be done by us without any aid from the contractors. It is true that we might have to consult them occasionally as to the ability of their shops to do certain work in a certain way; but most assuredly we would never have to ask their assistance in making the plans.

A true bridge expert is an engineer who is thoroughly posted in every detail of designing and construction, and who has had ample experience not only in the designing office, but also in the rolling mills, the bridge shops, the testing room, and the field. It is in the defence of such engineers that I am sending you this letter.

Very respectfully yours,
J. A. L. Waddell.

Kansas City, Mo., Jan. 25, 1908.

Waddell's Tests of Carbon-Steel and Nickel-Steel Columns.

Sir: Mr. Waddell's column tests, given in Engineering News of Jan. 16, 1908, add a little more data to our information concerning the failure of columns. As there is some prospect of more frequent investigations along this line in the future, let us hope that the engineers directing the work will see that tests are made on machines properly built to permit the taking of complete data, and that the operator is provided with the necessary equipment and knows how to use it. Mr. Waddell says it proved to be a very difficult matter to determine the elastic limit. Having personally made many tests on the Phoenix machine, both alone and while assisting an engineer of the Bureau of Buildings of the City of New York, I cannot only indorse that statement, but am quite sure that as the machine is now equipped, it is utterly impossible to properly fix the elastic limit in a compression test. The figures given by Mr. Waddell, showing a most wonderfully uniform set of values for that function, can safely be called guesses.

The maximum load, however, is readily noted by a careful observer, and in making some comparisons between Mr. Waddell's tests and my own, from a somewhat different point of view than taken in his article in your issue of Jan. 16, the maximum loads alone will be considered.

Mr. Waddell evidently overlooked the statement that "an average of 221 tests of the steel used indicates an elastic limit of 39,900 lbs." when he wrote that my records give "a single elastic limit of 39,000 lbs." The trick of raising the elastic limit, and the maximum strength, too, by speeding up the machine was well known to engineer inspectors all of twenty years ago, and has made many arguments necessary with tonnage representatives before we could get the proper reductions in speed of the screw machines used for specimen tests. All of my determinations were made at low speeds and some were checked with the Henning recorder; and Mr. Waddell's statement that "it is evident that in all probability there was no important difference in the strength of Mr. Buchanan's steel and mine" covers the case as well as may be.

While the general law is what is desired ultimately, it will hardly be questioned that members of like kind may be compared with more satisfactory results than can those of symmetrical and unsymmetrical form, or a mixture of both with a series of either. As my tests included four posts of steel, these may be compared with Mr. Waddell's six posts of carbon-steel and his method of comparison will be used so that the results may be comparable with his deductions.

Posts III., IV., IX., and XVII. of my tests had an average length-ratio of 77 and a crippling strength of 31,660 lbs. per sq. in. Mr. Waddell's formula gives 9,840 for $\frac{L}{r} = 77$ and 11,680 for $\frac{L}{r} = 54$, which is the average length-ratio of his six tests. Since 9,840/11,680 = 0.842, the average of 34,850 reduced by his method to $L/r = 77$ is therefore 29,340, or 93% of the mean value obtained in my tests.

Perhaps it may be said that members of very different length-ratios are not properly to be compared. We will therefore take III., IV., and IX., with averages of 87 and 31,650, and compare them with Mr. Waddell's three having a length-ratio of 81 and average of 30,500 lbs. Following the same method, we get 9,040/9,520 = 0.95, which gives 28,975 as the reduced value for his tests, or 90% of the average for my tests III., IV., and IX.

Again it may be said that posts III. and IV. were of a better type than Mr. Waddell's posts; and indeed the Cincinnati Southern tests made by Mr. Bouscaren and published in Vol. IX., Trans. Am. Soc. C. E., 1886, do show varying results in different types, so comparison may be made with No. IX., a latticed column of admittedly poor design. This post had a length-ratio of 97 and maximum strength of 27,790 lbs. per sq. in. For Mr. Waddell's three columns having $L/r = 81$, we get, reducing them to the length-ratio 97, a value of 8,240/9,520 × 30,500 = 26,400, or only 95% of the strength of the column which Mr. Waddell has very properly said he would not think of using with such a high value of L/r as 97.

The remarks Mr. Waddell makes in speaking of column XVI. are so surprising that it seems well to give some details in regard to the chord tests, lest others be led astray. In all chord tests, the end section was selected, and the test chord was built symmetrical about the cen-

TESTS OF FULL-SIZE COLUMNS, AND COMPARISON WITH FORMULAS.

Formulas: Dagron's Tests, $P = 61{,}000 - 263\ l/r$.
Buchanan's and Waddell's Carbon-Steel Tests, $P = 47{,}000 - 178\ l/r$.
Waddell's Nickel-Steel Tests, $P = 79{,}000 - 388\ l/r$.

Author.	No.	Length, inches.	Area of cross-section, sq. ins.	Rad. of gyration.	Length-ratio.	Strength. Computed.	Strength. Actual.	Per cent. of For.	Av. %
Dagron	1	192	8.24	4.567	42	50,000	41,020	82	..
"	2	192	8.24	4.567	42	50,000	41,650	83	..
"	3	240	8.24	4.567	52.6	47,200	39,440	84	..
"	4	240	8.24	4.567	52.6	47,200	41,650	88	..
"	5	288	8.24	4.567	63.1	44,400	40,230	91	..
"	6	288	8.24	4.567	63.1	44,400	40,070	90	..
"	7	307½	13.23	5.23	58.8	45,500	35,570	78	..
"	8	307½	13.23	5.23	58.8	45,500	38,810	85	85
Waddell	1SC	120	17.44	4.46	27	42,200	38,900	92	..
"	2SC	120	17.44	4.46	27	42,200	39,800	94	..
"	3SC	120	17.44	4.46	27	42,200	38,900	92	..
"	1LC	360	17.44	4.46	81	32,600	29,600	91	..
"	2LC	360	17.44	4.46	81	32,600	32,400	99	..
"	3LC	360	17.44	4.46	81	32,600	29,600	91	93*
"	1SN	120	17.44	4.46	27	68,500	68,500	100	..
"	2SN	120	17.44	4.46	27	68,500	68,500	100	..
"	3SN	120	17.44	4.46	27	68,500	69,200	101	..
"	1LN	360	17.44	4.46	81	47,600	44,400	93	..
"	2LN	360	17.44	4.46	81	47,600	47,200	101	..
"	3LN	360	17.44	4.46	81	47,600	42,500	89	98*
Buchanan	III.	156	15.25	1.87	83	32,200	34,270	106	..
"	IV.	156	14.15	1.87	83	32,200	32,900	102	..
"	IX.	300	14.22	3.10	97	29,700	27,790	94	..
"	XVII.	168	15.80	3.72	45	39,000	31,680	81	95

*Average of Mr. Waddell's 12 tests = 96%.

ter of panel, using at both ends the detail of the hip end, except that both ends were usually made square. This section, having an open joint, gets its whole load through the pin, and if the chords are correctly designed and pins properly located, the chords should (theoretically) fall upward as readily as downward, so that if the end section has an upward deflection, the adjoining section may deflect downward and so on alternately throughout the several panels, and thus produce very much the same conditions as if both ends were hinged.

Columns III. and IV. were properly detailed; the rivets became loosened in the pin plates on one side because the axis of last radius was at right angles to pin, and consequently the deflection was parallel to the pin, throwing practically all of the load on the plates on convex side of post, as was evidenced by the indenting of pins and loosening of rivets on this side only. Column III. was, through an error, improperly counterweighted, the counterweight being so large as to balance the whole weight of the post instead of its half weight; but with that perversity said to belong to inanimate things, the column failed by deflecting *down*, while Col. IV., properly counterweighted, failed *upward*.

I shall not attempt to defend the details of the earlier sections. That is one of the lessons of the tests; and while quite willing to admit that the later ones may not be perfect, they seem to have met the conditions that Mr. Waddell required of his Chief Draftsman in preparing the drawings for the test columns, i. e., they were so strong that failure occurred in the main portions of the members, though they were to all intents and purposes duplicates of the bridge members and were not specially designed for test purposes.

In 1884 and 1885, Mr. Jas. G. Dagron, since deceased, made some tests of posts (see Vol. XX., Trans. Am. Soc. C. E., 1889) which were similar to those designed by Mr. Waddell, though of a different grade of steel. Mr. Dagron used the same device in measuring change of length that had been used by Mr. Bouscaren in making the Cincinnati Southern tests and, while neither as sensitive nor as accurate as the Henning extensometer, seems to have given measurements that indicated very uniform moduli in the entire lot of columns. Although the vertical and horizontal deflection, and the compression of the column under each application of pressure, and its permanent deformation after each release, were carefully measured, Mr. Dagron unfortunately omitted to report the details so that, as he gave no elastic value, that property cannot be even approximately fixed. However, he gives the average elastic limit of the material in tension as 52,840 lbs. per sq. in., with a maximum of 84,100 lbs. per sq. in.

Not knowing how Mr. Waddell derives his constants nor what relation they bear to the maximum or crippling strength of the columns, the post tests made by Messrs. Dagron and Waddell and myself will be compared with results obtained through Mr. T. H. Johnson's formula, as determined from the given or assumed properties of each class of material.

Mr. Johnson has said that the K in his formula $P = K - C\frac{L}{r}$ varies as the carbon content of the steel. This evidently would not be true in the case of the introduction of other than the ordinary elements, such as an excess of manganese, nickel, or vanadium. In several examples available, it is found that the elastic limit in tension varies as the carbon content in ordinary carbon-steel, so it will be assumed that the value of K varies as the elastic limit in tension.

Mr. Waddell says his nickel-steel had a maximum strength of from 100,000 to 115,000 lbs. per sq. in. and an elastic limit of not less than 60,000 lbs. per sq. in. minimum, or probably two or three thousand pounds higher actually. The manufacturers guarantee for carbon-steel an elastic limit of 50% of the maximum, and it rarely if ever falls below 55% (it was 60% in my tests). The Carnegie Steel Co., makers of the steel for Mr. Waddell's columns, guarantee an elastic limit equal to 62½% of the maximum strength in nickel-steel. While my experience does not permit me to say positively as to nickel-steel, the fact that its high elastic limit is one of the points named in its favor makes it extremely likely that, as in the case of carbon-steel, the guarantee is on the safe side; I have therefore taken the elastic limit at 62½% of the average maximum, or 67,000, feeling that this is making a better showing for the nickel-steel than would be shown if the actual results obtained in the specimen tests were available. Even so, the following table confirms the analysis under Mr. Waddell's method, and makes it appear that a claim for material superiority in either set of results might call for the services of a special pleader to sustain it.

C. P. Buchanan.

Union Station, Pittsburg, Pa., Jan. 24, 1907.

Notes and Queries.

In the column tests reported by Mr. J. A. L. Waddell in our issue of Jan. 16, 1908, the limiting percentage of sulphur in the material of the nickel-steel columns was stated as 0.30%. This of course was an error of printing. R should read 0.03% sulphur.

A PLEASING CONCRETE BLOCK RESIDENCE.

In the accompanying half-tone we reproduce an example of residence construction in which a remarkably well balanced and artistic effect has been produced by a rational use of concrete block in the walls. No attempt has been made in any way to imitate stone masonry or to conceal from the casual observer that concrete block has been used. Instead the blocks have been made of uniform size, with a rough face finish and laid up in thick mortar joints with enough simplicity of line to lend dignity and at the same time to avoid unrelieved plainness. The design is to be commended for the absence of the great number of complicated molds and cornices which have done so much to bring concrete block architecture into disrepute.

The house was built for Mr. W. A. Taylor at New London, Conn., under a design by Messrs. Lord & Hewlett, Architects. All walls and partitions are of the two-piece hollow construction of The American Hydraulic Stone Co., of Denver, Colo., in which the individual blocks are T-shaped and are laid up alternately facing the inside and outside of the wall, thus leaving a large air space in the middle of the wall.

CONCRETE BLOCK RESIDENCE AT NEW LONDON, CONN.
Lord & Hewlett, Arch's.; Concrete Block System of American Hydraulic Stone Co.

REPORT OF THE NEW YORK STATE WATER SUPPLY COMMISSION.

The New York State Water Supply Commission, which is charged with the supervision of the taking of land and water rights for municipal supplies, with constructing flood prevention works, and with making a comprehensive study of the possibilities of public development of water powers in the State, submitted its annual report to the legislature on Feb. 1. From advance pages of the report we abstract certain interesting statements.

After outlining its action on petitions for new or increased water supplies, and urging the importance of systematic efforts to prevent water pollution, the commission suggests the need of State supervision of the construction of dams:

(1) Because of the danger that water stored for power purposes by a private corporation might in the future be required for domestic consumption by some civil division of the State; (2) because of the possible danger to life and property arising from insecure, cheap and improper construction of dams; (3) because of the danger to the public health from unsanitary conditions and surroundings, especially where waters stored for power purposes are drawn down in the heat of midsummer; (4) because without requiring the consent of the State authorities, private interests may secure riparian rights that will interfere with the interests of the State in developing water powers of its own; (5) because the scenic beauties of the State may be obliterated or defaced, where personal and private interests only are consulted by water power owners.

The duties of the River Improvement Commission, created in 1904, having been placed on the State Water Supply Commission in 1906, the latter body is now charged with passing on applications for relief from flood conditions, with estimating the cost of prevention works, and with apportioning that cost on the property benefited—the State, in the first instance, meeting the expense.

Accordingly, plans for the improvement of Canaseraga Creek and tributaries, in Mount Morris and other towns in Livingston Co., have been made and filed as required by law. These improvements would deepen and straighten the creek and remove obstructions therefrom, and at the same time reduce the length of the creek from 21 to 15 miles, between Cumminsville and the Genesee River. It is estimated that the improvements would shorten by half the time of flow of the stream between the points named, so the creek floods would reach the Genesee River many hours before the waters of the upper Genesee reach the junction of the two streams. This would "reduce to a minimum the damming up and setting back of the flood waters of these two streams, which now follow a simultaneous meeting of their flood waters." The plans for this improvement received legislative approval in 1907, but the condition of the money market prevented the sale of bonds at the 4% interest rate provided for by the legislature. Subsequently, a property-holder whose land was to be condemned questioned the constitutionality of the River Improvement Act (Chap. 734, Laws of 1904), so nothing further will be done until a court decision is obtained.

Under Chap. 569 of the Laws of 1907, the New York Legislature appropriated $35,000 for the investigation, by the State Water Supply Commission, of the water powers of the State. The commission was instructed to make a preliminary report to the legislature by Feb. 1, 1908, which it has done, and, if possible, a final report by Feb. 1, 1909. Mr. John R. Freeman, M. Am. Soc. C. E., of Providence, R. I., was engaged to direct the necessary engineering studies. Mr. Freeman's detailed report will soon be submitted to the legislature.

The commission estimates that, owing to lack of water storage, some 55% (550,000 HP.) of the potential energy of the streams of the State, not including the Niagara and St. Lawrence rivers, is wasted every year. Estimating "the advantage of water over steam power" at $12 per HP. per yr., this wasted energy represents $6,600,000, besides $1,000,000 of flood damages that might be saved by water storage. State storage dams, the commission believes, would (1) decrease flood damages; (3) improve sanitary conditions by increasing minimum stream flows; (3) improve navigation in the Hudson and in the canals; (4) "provide cheaper power for manufacturing purposes, and, by stimulating various industries, furnish larger fields of employment, while insuring uninterrupted labor in already existing plants"; and (5) storage would "provide a satisfactory income to the State," over and above the cost of the improvements.

Studies of water storage possibilities on a number of streams have been made and are outlined in the report. Two may be outlined here:

A dam on the Sacandaga River, near Conklingville, Saratoga Co., would flood some 40 sq. mi., store 26,000,000,000 cu. ft. of water, and produce 50,000 HP., besides increasing the dry-weather horse-power on the Hudson, below. The dam would set back the river to Northville, flooding a number of small Southern Adirondack settlements, and also flooding about four miles of the Fonda, Johnstown & Gloversville Railroad. The shore line of the proposed reservoir would be so treated as to make "an attractive sandy beach when the water is drawn down."

A dam on the Genesee River, at Portageville, just above Letchworth Park (a recent gift to the State), would store 18,000,000,000 cu. ft. of water, provide 32,000 HP., and add 14,000 HP. to that already developed at Rochester. In addition, such a dam would prevent flood damages on the Genesee flats and to property in Rochester, besides affording dry-weather sewage dilution for Rochester that might relieve that city from the necessity of building an expensive trunk sewer. The dam proposed at this point would be 160 ft. high above its foundation, 1,200 ft. long on the crest, curved in plan, and would form a lake with an area of 15 sq. mi. The power-house would be located below Letchworth Park, about five miles from the dam, as the river flows. The supply conduit would give a net working head of 500 ft., and for three miles of its length it would be an 18-ft. tunnel.

Mr. Henry H. Persons is President of the State Water Supply Commission, and Mr. Walter McCulloh, M. Am. Soc. C. E., is Consulting Engineer. The offices of the commission are at Albany, N. Y.

OTHNIEL FOSTER NICHOLS.

By R. S. BUCK,* M. Am. Soc. C. E.

The engineering profession has rarely suffered such a shock as was inflicted by the sudden death of Othniel Foster Nichols on Feb. 4, not only because of his activity, prominence, popularity and value, but because, despite his approach to the sobering milestone of "three score and ten," there was, to the last, nothing about him that suggested age or waning powers.

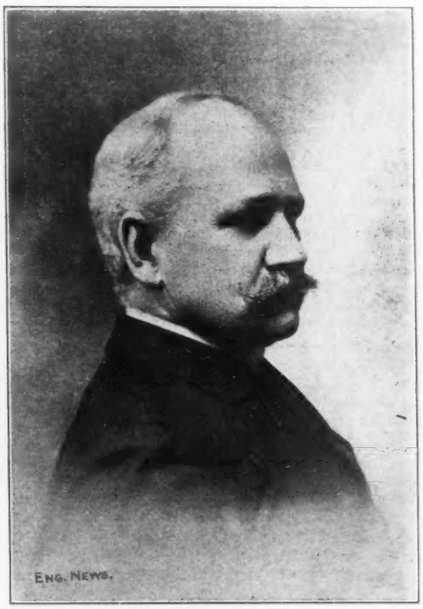
Few engineers were more widely or favorably known than Mr. Nichols, not only because of his active professional work in many quarters of the globe, but because of his great personal charm, his strong human interest, his generous sympathy. Few men have contributed more of their efforts to the welfare of others, or more promptly extended a helping hand. To the young men of the profession he has always shown the deepest interest, and with them his never failing youth of heart and mind always formed a strong and happy bond.

Mr. Nichols was born in Newport, R. I., July 29, 1845. He was the son of Thomas Pitman and Lydia Foster Nichols. On his mother's side he was directly descended from John Foster, of Salem, Mass., who settled in Rhode Island early in the seventeenth century. On his father's side he was a descendant of Sergeant Thomas Nichols, who, after emigrating from Wales to the Island of Barbadoes, came to Newport in 1660—two of his descendants being Deputy Governors of the Rhode Island Colony, and others being largely interested in shipping affairs.

Mr. Nichols attended the public schools of Brooklyn, N. Y., and was apprenticed as a machinist in 1862, afterward entering the Rensselaer Polytechnic Institute, where he was graduated in 1868 as civil engineer. After assisting in the engineering development of Prospect Park in Brooklyn, and of the first elevated railway in New York City, and teaching mathematics in the night schools of Cooper Union, he became, in 1870, assistant engineer in the office of Cooper, Hewitt & Co.

After 1871, he was four years in Peru, most of the time engaged in tunnel work, locating and constructing the tunnel division of the Chimbote & Huarez Railway (of the Meiggs system). Returning to the United States in 1876, he served as assistant engineer and superintendent for the Edgemoor Bridge Works, in the construction of the Metropolitan Elevated Railway in New York City, and was afterward employed in the Park Department as engineer in charge of the drainage sewer for the annexed district. In 1878 he went to Brazil as resident engineer and attorney of the Madeira & Mamore Railway, an English enterprise which ended in protracted litigation which took Mr. Nichols to London.

Returning to the United States in 1879, he again entered the employ of Cooper, Hewitt & Co., and served two years as assistant engineer in the bridge shops of the New Jersey Steel & Iron Co., at Trenton, N. J., and in other enterprises of that company. In 1882, he was resident engineer of the Henderson Bridge over the Ohio River, and in 1886 chief engineer of the Westerly Water-Works Co., of Westerly, R. I., resigning this position to become principal assistant engineer of the Suburban Rapid Transit Co., in New York City. In 1888 he was made chief engineer of the Brooklyn Elevated Railroad Co.,



O. F. Nichols

and in 1892 he became general manager of the same company.

From 1895 to 1902, he was principal assistant engineer of the Williamsburg Bridge over the East River. In 1902-3 he was principal assistant engineer of the Department of Bridges, City of New York, in charge of the Williamsburg Bridge. In 1903 he was engaged as consulting engineer upon the work of depressing the right-of-way of the Brighton Beach division of the Brooklyn Rapid Transit R. R. to Coney Island. In January, 1904, he was appointed chief engineer of the Department of Bridges, New York City, and early in 1906 was made consulting engineer for the same department, which position he held at the time of his death. The new Manhattan Bridge, now in process of erection over the East River, was under his charge at the time of his death.

Mr. Nichols was a member of the American Society of Civil Engineers, American Society of Mechanical Engineers, British Institution of Civil Engineers, Engineers', Railroad, Crescent and Municipal Clubs, and various other scientific and social organizations. He was also widely known as a writer and lecturer upon technical subjects. He was president of the Engineering Department, Brooklyn Institute, trustee of the Brooklyn Polytechnic Institute, and a vestryman of St. Luke's P. E. Church in Clinton Ave., Brooklyn.

Mr. Nichols leaves a wife and two daughters, Mrs. Arthur L. Perry, of Westerly, R. I., and Miss Margaret Foster Nichols.

Mr. Nichols died as all men should wish to die: he retained until the last moment his full vigor of mind and body, his full power of enjoyment of a vigorous, active, happy life. The call came swiftly and painlessly, and into the great unknown beyond he stepped as quietly as through the gates of sleep.

*52 William St., New York City.

AN EXPLOSION IN THE POWDER MILLS of the Du Pont Powder Co., at Gibbstown, N. J., on Feb. 5, caused damage to the buildings to the extent of $75,000. No one was injured by the accident.

A COAL MINE EXPLOSION in the Porthood coal mines at Porthood, Nova Scotia, on Feb. 7, caused the death of ten miners. The mine is a small working employing at the maximum about 100 men. The cause of the explosion has not been reported.

A PASSENGER TRAIN on the Western Maryland R. R. jumped the track on a curve near Gormania, W. Va. on Feb. 7, and rolled down a 40-ft. embankment to the ice on the Potomac River. Two persons were killed and 24 injured. On the same day a Pennsylvania R. R. train, known as the "Washington Express," en route from Washington to Buffalo, jumped the track near Franklinville, N. Y., and wrecked the two coaches which comprised the train. No one was killed, but about 20 persons were injured.

THE FORMAL INSTALLATION of Dr. W. F. M. Goss as Dean of the College of Engineering of the University of Illinois occurred Feb. 5 in connection with the opening of the Graduate School. The exercises of installation included two sessions and a tour of inspection through the engineering laboratories. The program included addresses by President E. J. James, Mr. W. L. Abbott, President of the Board of Trustees, Dean W. F. M. Goss, Mr. Robt. W. Hunt of Chicago, and Mr. W. A. Smith of Chicago.

ORDERS FOR 55,000 TONS OF RAILS were placed by the Pennsylvania R. R. Co., on Feb. 6 under specifications which place on the manufacturers the responsibility for the quality of the material furnished. Each rail is to be stamped with a letter indicating the part of the ingot from which it was rolled. It is expected that part of the order will be filled with open hearth rails, in order that a comparison of the service of these rails may be made with rails rolled at the same time from Bessemer steel.

FULL-SIZE EYEBAR TESTS at the Ambridge plant of the American Bridge Co. showed, in 570 tests, an elastic limit equal to 52½% of the ultimate strength of the full-size bar. This information was given by Mr. H. S. Prichard in a discussion recently before the Engineers' Society of Western Pennsylvania. In further explanation, Mr. Prichard states that the ultimate strength of a full-size eyebar is likely to be 10% or more below the ultimate strength shown by specimen test (small size), but the reduction varies with the annealing. The practice of the American Bridge Co. is to furnish eyebars either for acceptance on specimen test or for acceptance on full-size test, but both tests must not be specified by the purchaser. When full-size tests are specified, the bars will meet the requirement of 55,000 lbs. per sq. in. minimum ultimate strength, with 15% elongation in 10 ft. This strength figure gives an elastic limit, according to the ratio above stated, of about 29,000 lbs. per sq. in.

SUPERVISION OF TOWN BRIDGE CONSTRUCTION in more effective manner than hitherto is proposed by State Engineer Frederick Skene of New York. There is at present a provision in the Highway Law that town officials may ask the State Engineer's office to inspect and certify to the proper construction of iron or steel bridges exceeding 200 ft. in length or having a span exceeding 100 ft., and may submit plans and specifications for such bridges to the State Engineer for approval. This provision has not been made use of to any great extent. The State Engineer therefore recommends that his approval as well as the approval of the County Engineer be required of the plans and specifications of every bridge exceeding $500 in cost to be built by a town. He also recommends that contracts for such bridges be required to be awarded to the lowest bidder, after the work has been properly advertised, and finally that the approval of the State Engineer be required before payment for a completed bridge is made.

FOR THE INTERNATIONAL EXHIBITION of the Applications of Electricity to be held in Marseilles, 1908, as noted in Engineering News, Jan. 30, it has been decided to re-erect the Grand Hall used for the Bor-

deaux Maritime Exposition to supplement the buildings already planned. On account of the greater space thus available, the space rates will be reduced and additional groups have been created for which exhibits are solicited. These groups will include prime movers and generating apparatus, belts, transmission cables, etc. It has been decided to hold an International Congress on the Applications of Electricity from Sept 14 to 21. General and section meetings, lectures and excursions are planned. Admission fee to the congress will be about $4. Full details can be obtained from the Commissioner for the United States, Mr. Paul Diény, Park Row Bldg., New York City.

HEAT TRANSMISSION DOWNWARD INTO THE earth was studied in experiments made recently by the Fire Department of the city of Hanover, Germany. Three flat piles were made of dry sand, gravel (slightly moist), and building debris; these piles were about 3 ft. high, with side slopes of 45° and a square flat top large enough for the erection of a brick furnace. A furnace was built on each pile, 32 ins. high, of 5-in. brick walls, with draft openings on opposite sides; the top of the pile of fill formed the floor of the furnace. Coke fires were started in these furnaces and kept up by feeding of coke continued for several days. Fusible cones were used to measure the furnace temperature; they showed 2,200° F. at the base of the fire, but it was concluded that the fire rose over 2,500° F. as the brick walls showed incipient fusion. Thermometers were set in the piles of fill at depths of 4 ins., 12 ins., 20 ins., 30 ins. and 40 ins. below the furnace floor. It was found that at the depth of 40 ins. only small rise of temperature occurred, even after several days. At 20 ins., the temperature of 100° F., which is about the boiling point for commercial light oils such as benzine, was reached only after the fire had been burning 46 hrs. Even at 4 ins. depth the temperature remained at 212° F. for a long time, probably from the effect of the water in the material of the fill. The following temperatures were reached in 21 hrs. in the pile of building debris:

Depth.....	4 ins.	Temperature.....	518° F.
"	12 ins.	"	185° F.
"	20 ins.	"	122° F.
"	30 ins.	"	68° F.
"	40 ins.	"	63° F.

It was concluded from these tests that relatively small depths of soil protect efficiently against the heat of a fire above, and that tanks containing inflammable liquids are sufficiently protected if their top is at least 20 ins. below the ground surface.

DAMAGE BY AUTOMOBILES TO MACADAM ROADS in New York State appears to be extensive. In the past two or three years the increase in the number of automobiles and in their weight and speed has made their effect noticeable. The fragments and powder formed by the grinding action of traffic, which serve as a necessary binder to the stone of the macadam, are lifted up by the broad rubber tires of a rapidly-moving automobile and scattered. A report of the engineer in charge of the Middle Division of roads expresses this as follows:

> After a heavy motor car with rubber tires has passed over a macadam road at high speed, the wheel tracks may be followed readily by the eye, as the tires have sucked out the fine material from the surface for a width of four to six inches, leaving the sharp edges of the larger fragments exposed to the next iron-tired vehicle, which breaks off the sharp edges and smooths up the surface by crowding the chips broken off into the voids. The next motor car throws out the fine particles again leaving the roughened surface, which is again ground off by the iron tires, and thus the rapid deterioration progresses.

The report of the State Engineer for 1907 quotes expressions of similar experience in other States and in foreign countries, all uniting in the statement that macadam roads are being injured very seriously by automobile traffic. The State Engineer also refers to the great damage done by the direct picking action of tire chains and other non-skidding appliances. In the parks of New York City and in some other places the use of such appliances has been forbidden. The State Engineer makes no specific recommendation to protect the State roads, but recommends the subject to the consideration of the Legislature. He remarks that the law now permits no greater speed than 20 mi. per hr. on the open highways of the State, but that "it is a matter of common knowledge that this law is more honored in the breach than the observance."

THE ELEVATED RAILWAY LOOP problem at Chicago is to be investigated by engineers on behalf of the city, the council committee on local transportation having decided to take this step in an endeavor to arrive at some solution that will give more than temporary improvement. The railway companies desire to lengthen the platforms and to establish stub terminals outside the loop, so as not to run every train around the loop. Both these plans are objected to as increasing the depreciation of property values, while the latter would mean inferior service for many passengers. Double-deck structures at the junctions, to avoid the present grade crossings, are also objected to as still further darkening the streets. The proposition made by Mr. B. J. Arnold, as consulting engineer for the city, to run through trains is not approved by the companies. By this arrangement a north side train would pass around two sides of the loop and continue its way to the south side, instead of passing entirely around the loop and returning to the north side. This system is being introduced on the surface lines, all of which have until now made dead-end or loop terminals in the center of the business district. Mr. C. V. Weston, President of the South Side Elevated Ry., has proposed intersecting lines within the loop, so as to form four separate loops, each for the exclusive use of one of the railways. Transfers would be effected at a central station, and any block or congestion of traffic on one road would not affect the others, as is the case under the present system by which the trains of all four lines pass around the loop.

THE LAWRENCE AVE. SEWER TUNNEL at Chicago has been completed after ten years of construction and litigation. It is the end of the intercepting sewer system on the north side, by which all sewage will be discharged into the north branch of the Chicago River. There will also be an intake at the lake end, to admit dilution water and also to give the necessary amount of flow in the Chicago River. The 39th St. tunnel fulfilling the same purpose on the south side was completed some time ago, and its pumping plant was erected last year.

CABLEWAY AND RACK-RAILWAY projects for facilitating access to the Grand Canyon of the Colorado are periodically mentioned in the daily press, but the Atchison, Topeka & Santa Fe Ry. (which is usually credited with these projects) has not prepared plans or estimates for any such schemes. The principal foundation for the report seems to be that a cable-trolley crossing of the river has been established at the bottom of the canyon, but this is an inexpensive affair and is not owned by the railway. It is similar in plan to the system used in many of the rocky canyons in the west. On a fixed cable runs a trolley from which is suspended a cage capable of holding one or two persons, the passenger pulling the cage across by means of a small subsidiary cable.

PERSONALS.

Mr. Eads Johnson has recently taken charge of the New York office of the New York Shipbuilding Co., to succeed Mr. W. D. Dimock, resigned.

Mr. John L. Heins, for the past 24 years President of the Coney Island & Brooklyn R. R. Co., has retired from that office but will remain in the service of the company as Chairman of the Board of Directors.

Mr. Richard Quinn, M. Am. Soc. C. E., U. S. Assistant Engineer, has been transferred from the fortification works at New Orleans, La., to the Philippine Islands, with headquarters at the U. S. Engineer office, Manila, P. I.

Mr. T. S. Reilly has been appointed Mechanical Superintendent of the Canton & Hankow Ry., with headquarters at Canton, China. Mr. Reilly has been recently an Associate Editor of the "Railway and Engineering Review," of Chicago.

The Riggs & Sherman Co., Consulting Engineers of Toledo, Ohio, have been retained by the City Council of Salem, Ohio, to appraise the property of the privately owned water-works plant of that city, with a view either toward renewing the franchise or municipalizing the plant.

Mr. Milton W. Wilbur, of the State Engineer's Department of the State of New York, was the guest of honor at Rochester on Jan. 30, at a dinner in celebration of the completion of 26 years' continuous service in the department. Mr. Wilbur is now First Resident Engineer of the Western Division and is interested chiefly in road development.

Mr. A. H. Van Cleve, M. Am. Soc. C. E., who has for the past 16 years been connected with the Niagara Falls Power Co. and allied companies, has retired from the office of Resident Engineer to enter into a general engineering practice, specializing in water power developments. He will still retain a connection with the Niagara Falls Power Co. as Consulting Engineer.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN INSTITUTE OF MINING ENGINEERS.
Feb. 18. Annual meeting at New York. Secy., R. W. Raymond, 29 West 39th St., New York.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
March 17-19, 1908. Annual convention at Chicago, Ill. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago.

AMERICAN WATER-WORKS ASSOCIATION.
May 11-16, 1908. Annual meeting at Washington, D. C. Secy., John M. Diven, 14 George St., Charleston, S. C.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 23-26, 1908. Annual convention at Denver, Colo. Secy., C. W. Hunt, 220 West 57th St., New York City.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
June 23-26, 1908. Annual convention at Detroit, Mich. Secy., C. W. Rice, 29 West 39th St., New York City.

ILLUMINATING ENGINEERING SOCIETY.—The New York Section will meet at the Engineering Societies Bldg., on Feb. 13. Mr. G. L. Hunter, a specialist in tapestries and decoration, will present a paper on "Light and Color in Decoration."

THE GEOLOGICAL SOCIETY OF AMERICA.—The following officers have been elected for the coming year: President, Mr. Samuel Calvin, Iowa City, Iowa; 1st Vice-Pres., Mr. George F. Becker, Washington, D. C.; 2d Vice-Pres., Mr. A. C. Lawson, Berkeley, Cal.; Treasurer, Mr. W. B. Clark, Baltimore, Md.; Secretary, Mr. Edmund Otis Hovey, American Museum of Natural History, New York City.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—At the regular meeting on Friday, Feb. 14, at 8 p. m., the following papers will be presented: (1) "The Non-Synchronous Generator in Central Station and Other Work," by W. L. Waters, Electrical Engineer, Westinghouse Electric & Manufacturing Co., Pittsburg, Pa. (2) "Some Developments in Synchronous Converters," by Charles W. Stone, Electrical Engineer, General Electric Co., Schenectady, N. Y. (3) "Some Features of Railway Converter Design and Operation," by J. E. Woodbridge, Electrical Engineer, General Electric Co., Schenectady, N. Y. It is expected that the discussions will be led by the following men: Charles F. Scott, Consulting Engineer, Westinghouse Electric & Manufacturing Co., Pittsburg; J. B. Taylor, Electrical Engineer, General Electric Co., Schenectady, N. Y., and Frank G. Clark, Electrical Engineer, Pennsylvania Tunnel and Terminal Railroad, L. I. City. Members of the American Institute of Electrical Engineers are cordially invited to attend the session of the American Institute of Mining Engineers, in the Engineers' Building, Tuesday evening, Feb. 18, when paper will be read by D. B. Rushmore, of Schenectady, on "Electric Power in Steel Mills." Arrangements may then be made to attend certain excursions on Feb. 20 and 21.

INTERNATIONAL CONGRESS OF REFRIGERATING INDUSTRIES.—This meeting will be held in July, 1908, in Paris, under the direction of the French Government. The Secretary-General is M. J. de Loverdo, 10 Rue Poisson, Paris, to whom all inquiries should be directed. The work of the Congress has been laid out in six sections, each of which is under the control of a special committee, headed by a president chosen from the most eminent specialists of France, as follows: Section I. Low temperatures and their general effects, physical, chemical and biological. General and alimentary hygiene; dietetic value of chilled and frozen food materials. Section II. Refrigerating appliances; refrigerating machinery; industrial methods for the production of cold; compression of liquefiable gases and air; absorption, etc. New apparatus; unification of refrigerating measures; proposed units; practical methods of testing refrigerating machines; determination of refrigerating power; employment of wet or dry refrigeration; the construction of cold storage buildings; experimental data as to the different insulating materials and methods of testing the same; the use of refrigeration in magazines for explosives and in abattoirs; distribution of cold, central stations, etc. Section III. The application of refrigeration to food, viz., causes and effect of changes in the condition of perishable products while in cold-storage chambers; colonial products capable of benefiting by refrigeration; artificial cold in the manufacture and preservation of butter; cold-storage organization of warehouses and central markets; victualing of besieged towns and troops in field campaign service; preservation of fish and refrigerating installations on seagoing fishing vessels. Section IV. The application of refrigeration to other industries, viz., the retardation of flowering of plants by the application of cold; preservation of flowers; the influence of refrigeration on the clarification of fermented beverages; ice manufacture, the best methods of obtaining pure table ice and of preventing contamination. Mines, metallurgy, public works. Stearine, paraffin, margarin, etc. New industrial applications of refrigeration. Section V. The application of refrigeration to commerce and transport, viz., the progress of trade in perishable produce since the adoption of refrigeration; organization of cold-storage transport on railways; refrigeration cars, cold-storage warehouses and charges; organization of cold-storage transport by sea. Section VI. Legislation, viz., laws and regulations to be modified; state encouragement given in various countries to the refrigerating industry; the sale during the closed season of cold-stored game and fish; questions of insurance; the value of refrigeration in the food supply of the poorer classes.

Memberships are of three classes, viz.: Donor members, who pay a subscription of not less than $20; ordinary members, who may be individuals, firms, or companies, and pay as subscription $4; and associate members, who must be a family relative—wife, brother, sister, or child of a donor or ordinary member. The value of an associate membership consists in the fact that it will entitle the holder to all concessions by railways, steamship lines, etc., and to admission to the sessions of the congress and the various fêtes and receptions which will be offered in Paris to visiting members and their families.

LEADING ARTIC
A Reinforced-
Garden (Il
Treating Woo
David Alle
A Cement Sta
bers .....
Sheathing Pie
A Traveling M
man, M. A
Bench Level
Zipser ...
The Water H
Chemical Pre
Machinery an
and Chem
Annual Meeti
Recent Impro
Machine (

A REINFORCED-
DOMES: CI

An interesti
concrete for st
character is af
ing in the Zoo
general view
a cross section
77 × 155 ft. I
ft. wide, and
The central b
lic, while in t
for the ani
architectural
Moorish in c

The soil is
clay, so that
low foundati
quired, and t
of flat footin
ing the wall
columns. The
rying the ro
upper part
tral bay are
longitudinal
top and bo
of the latter
to an incline
so as to p
the top of th
column
thus providi
shear. The
forcement fo
girders (in
the inclined
bars) consi
verse stirru
The chara
construction
Fig. 3. T
roofs are a
and a num
features w
including
in some o
stalls for
hippopotam
interior c
octagonal
24 ins., re
tied toget
They have
place, the
walls are
columns, s
wide on t
the colum
wall. Th
angular, 1
hooped a
spaced 24

The cor
cement t
gravel, m